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(54) Fuel supply system and vehicle

(57) The invention relates to a fuel supply system comprising an air intake chamber (5b) having an air inlet opening, an air intake path (9) including an aperture (24a,42a) that opens towards an inside of the air intake chamber (5b) for guiding the air in the air intake chamber (5b) from the aperture (24a,42a) to an engine (13), and an injector (18) for injecting fuel between the air inlet opening and the aperture (24a,42a).

The invention aims to provide an improved fuel supply system and a vehicle, wherein an engine performance can be improved with sufficient fuel supply when an engine is at the high speed and high load operation.

Therefore, the invention provides that in the air intake path (9), an inner surface of the aperture (24a,42a) is continuous to a bottom surface (4d,4e) of the air intake chamber (5b).

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Description

[0001] The invention relates to a fuel supply system comprising an air intake chamber having an air inlet opening, an air intake path including an aperture that opens towards an inside of the air intake chamber for guiding the air in the air intake chamber from the aperture to an engine, and an injector for injecting fuel between the air inlet opening and the aperture. Besides, the invention relates to a vehicle, in particular being a straddle-type vehicle, comprising an engine and a fuel supply system.

[0002] A conventional injector for injecting fuel is generally placed downstream of a throttle valve in the airflow direction. Here, the throttle valve is provided to an air intake path that is directed from an air cleaner to an engine. The problem here is that such an injector (hereinafter, referred to as "downstream injector") is located closer to the engine, and thus the fuel injected from the downstream injector may flow into the engine without being fully atomized. Therefore, for the purpose of facilitating fuel atomization, a possible fuel supply system is of a type including an injector at a position away from an engine.

[0003] Specifically when the engine is at the high speed and high load operation, a downstream injector is not enough for fuel supply, requiring another injector upstream of a throttle valve in the airflow direction (hereinafter, such an injector is referred to as "upstream injector"). In such a fuel supply system, when the engine is at the high speed and high load operation, the fuel is injected not only from the downstream injector but also from the upstream injector.

[0004] With this being the case, not to make the air intake path longer than necessary even with the upstream injector, a possible structure carries the upstream injector inside of an air cleaner as it is shown, for example, in JP-A-07-332208.

[0005] FIG. 13 is a diagram showing the structure of such a fuel supply system. As shown in the drawing, in the conventional fuel supply system, a downstream injector 102 is placed downstream of a throttle valve 108 of a throttle body 106, which serves as an air intake path. Upstream of the throttle valve 108, an upstream injector 104 is placed inside of an air cleaner 100.

[0006] In a case of such a placing an upstream injector, a consideration has to be given to the fact that the fuel injected from the upstream injector will splash (hereinafter, referred to as "bubble over") outside of the air intake path due to air turbulence in the air cleaner, for example. There thus needs to suppress the amount of fuel coming from the upstream injector, or to bring the upstream injector closer to an aperture of the air intake path.

[0007] The issue here is that suppressing the amount of fuel coming from the upstream injector may result in shortage of fuel supply to the engine, and bringing the upstream injector closer to an aperture of the air intake path may not facilitate fuel atomization. That is, in spite of additionally including the upstream injector, the problem remains that there is no way of coping with the high speed and high load operation of the engine.

[0008] It is, therefore, an object of the invention to provide an improved fuel supply system and a vehicle, wherein an engine performance can be improved with sufficient fuel supply when an engine is at the high speed and high load operation.

[0009] For a fuel supply system of the above kind, this object is solved in an inventive manner in that in the air intake path, an inner surface of the aperture is continuous to a bottom surface of the air intake chamber.

[0010] Accordingly, the invention is capable of eliminating the need for suppressing the amount of fuel coming from the injector, or bringing the injector closer to the aperture of the air intake path, thereby successfully allowing sufficient fuel supply from the injector. Moreover, according to the invention, the fuel can be better atomized with the air intake chamber efficiently used in space. This thus favorably facilitates atomization of fuel to be injected from the injector, and the engine performance can be improved with sufficient fuel supply when the engine is at the high speed and high load operation.

[0011] In other words, according to the invention, fuel coming from the injector can be better atomized, and the engine performance can be improved with sufficient fuel supply when the engine is at the high speed and high load operation.

[0012] Preferably, the injector is provided inside of the air intake chamber, and/or in that in the air intake chamber, the bottom surface is sloped downwardly towards an outer edge of the aperture of the air intake path, wherein preferably the bottom surface is sloped at an angle of 45 degrees or less with respect to a horizontal plane.

[0013] Further, preferably the air intake chamber is configured to be capable of producing an airflow by the air from the air inlet opening along the bottom surface toward the aperture.

[0014] Furthermore, preferably the air intake path comprises a connection member that forms the aperture which preferably goes through the bottom surface of the air intake chamber from an inside of the air intake chamber towards an outside thereof; and wherein preferably a tubular member configured to establish a connection with the connection member from the outside of the air intake chamber, and/or wherein preferably the connection member is made of an elastic material.

[0015] Still further, preferably the injector is configured to inject the fuel from a vicinity of the air inlet opening, and/or in that the injector is configured to inject the fuel toward the aperture.

[0016] Also, preferably the injector is configured to inject the fuel with a timing coming into collision with a shock wave that is generated in the engine and which propagates through the air intake path in a direction toward the air intake chamber, wherein preferably the in-

jector is configured to inject the fuel with a timing coming into collision with the shock wave propagated into the air intake chamber.

[0017] Further, preferably the injector is configured to inject the fuel with a timing when an air intake valve opens between the air intake path and the engine.

[0018] Also, preferably in the air intake path, the aperture comprises a plurality of apertures being included in the air intake chamber, wherein preferably in the air intake chamber, a bottom surface among the apertures is formed with an edge line, wherein further preferably in the air intake chamber, an extended line of the edge line extends in a direction of the air inlet opening.

[0019] Further, preferably the air intake chamber is comprised in an air cleaner including an element for purifying air coming from outside, wherein preferably the element is provided upstream of the injector which is arranged to inject fuel between the element (8) and the aperture.

[0020] Furthermore, preferably in the air intake chamber, a bottom surface between the aperture and an inner wall opposite to an element for purifying intake air, the bottom surface including the aperture of the air intake path therebetween is sloped downwardly towards the aperture.

[0021] Also, preferably the air inlet opening comprises an air guide portion for guiding air at a section of the air intake chamber being upstream of the aperture, wherein, preferably; at least a part of the air guide portion is provided upstream of the injector.

[0022] Additionally or alternatively to any of the other solutions or embodiments, the above object is solved in an inventive manner by providing an air intake chamber including an element for purifying air coming from outside, and a through hole that is formed, to go through outside of the intake chamber, at a lowest portion of an inner surface of the intake chamber into which the air passed through the element flows, an air intake path for guiding the air through the through hole from the air intake chamber, and an injector for injecting fuel inside of the air intake chamber toward a portion upper than the through hole.

[0023] According to a further preferred embodiment of the invention, the fuel supply system is configured such that the air intake chamber includes a small-diameter portion formed by an inner edge wall surface of a through hole protruding toward a center, and/or the air intake path includes a connection member made of an elastic material, for attachment to the small-diameter portion and a tubular member for coupling to the connection member.

[0024] Still further, preferably the fuel supply system further includes an engagement member for engaging between the air intake chamber and the air intake path, wherein a tubular member of the intake path is engaged by the engagement member from an inside of the air intake chamber, and/or in that a connection member connecting the air intake path and the intake chamber is partially held firmly by the small-diameter portion and the tubular member.

[0025] Also, preferably a connection member includes a protrusion that protrudes into the air intake chamber, and wherein preferably the protrusion covers at least partially the engagement member.

[0026] Further, preferably a second injector is arranged to inject fuel into the air intake path at a position downstream of the aperture.

[0027] Further, more preferably a throttle valve is provided, which is positioned downstream of the aperture and/or upstream of the second injector.

[0028] Still further, preferably the injector is provided to be located at least partially within the intake chamber.

[0029] Moreover, preferably the injector is provided to be located at least partially outside the intake chamber.

[0030] Also, preferably the injector is provided to be located completely within the intake chamber.

[0031] Besides, for a vehicle of the above kind, the above object is solved in an inventive manner in that the fuel supply system is configured according to at least one of the claims 1 to 20.

[0032] Preferably, the vehicle further comprises an air intake port for capturing a running wind flowing from front to rear when the vehicle moves, an air intake duct for forwarding the captured running wind to an air inlet opening of the air intake chamber, and the air intake chamber preferably being placed rearwardly of the air intake port.

[0033] Further preferred embodiments of the invention are subject to the respective subclaims.

[0034] In the following, the invention will be described in greater detail by means of preferred embodiments thereof with reference to the attached drawings, wherein:

Fig. 1 is a side view of a vehicle according to embodiments of the present invention;

FIG. 2 is a cross sectional side view of a fuel supply system according to a first embodiment of the present invention;

FIG. 3 is an enlarged cross sectional view in the vicinity of an air funnel of the first embodiment;

FIG. 4 is another enlarged cross sectional view in the vicinity of the air funnel of the first embodiment;

FIG. 5 is a plan view of the bottom surface of an air cleaner of the first embodiment;

FIG. 6 is a cross sectional view cut along the line I-I of the fuel supply system of the first embodiment;

FIG. 7 is a perspective view of the bottom surface of the air cleaner of the first embodiment;

FIG. 8 is a cross sectional view cut along the line II-II of the fuel supply system of the first embodiment;

FIG. 9 is another cross sectional side view of the fuel supply system of the first embodiment;

FIG. 10 is a cross sectional view cut along the line II-II of a fuel supply system according to a second embodiment of the present invention;

FIG. 11 is a cross sectional view cut along the line I-I of the fuel supply system of the second embodiment;

FIG. 12 is another cross sectional view cut along the line I-I of the fuel supply system of the second embodiment; and

FIG. 13 is a diagram showing an exemplary conventional fuel supply system.

[0035] In the below, embodiments of the present invention are described in detail by referring to the accompanying drawings.

(First Embodiment)

[0036] FIG. 1 is a side view of an exemplary vehicle according to a first embodiment of the present invention. In the drawing, the left side viewed from the front is the front side of the vehicle, and the right side viewed from the front is the rear side of the vehicle. In FIG. 1, air captured by an air intake port 1 goes through an air intake duct 3 and reaches an air cleaner 5. The air is then purified by the air cleaner 5, and the resulting air is sucked into an air intake path 9 together with fuel coming from an upstream injector unit 7. In the air intake path 9, another fuel then comes from a downstream injector unit 11, and thus the air and fuel supply is made to the engine 13 in the stroke thereof for air intake. Note here that the engine 13 in the present embodiment is presumably a parallel four-cylinder engine, and it means that four of the air intake path 9 are provided.

[0037] In the engine 13, thus supplied air and fuel are both compressed in the stroke for compression. After power is generated as a result of explosion in the stroke for combustion, the resulting power is forwarded to an air exhaust path 15 in the stroke for air exhaust. The exhaust gas thus forwarded to the air exhaust path 15 is exhausted outside from a muffler 17.

[0038] In the following description, the upstream of an airflow directed from the air intake port 1 to the engine 13 through both the air cleaner 5 and the air intake path 9 is simply referred to as upstream, and the downstream of such an airflow is simply referred to as downstream.

[0039] FIG. 2 is a side cross sectional view of the fuel supply system according to the first embodiment of the present invention. The fuel supply system of FIG. 2 mainly includes the air cleaner 5, the upstream injector unit 7, the air intake path 9, and the downstream injector unit 11.

[0040] The air cleaner 5 is provided with an upper case 2, a lower case 4, an air intake port cover 6, an element 8, and a sub chamber cover 10.

[0041] The upper case 2 forms the upper outer portion of the air cleaner 5, and carries a concave portion 2a at the front portion of the edge abutting the lower case 4 to latch with the lower case 4. The upper case 2 is, at the rear portion, provided also with holes for attachment of the sub chamber cover 10, and around the holes, attachment portions 2b and 2c are respectively formed. To the attachment portion 2c that is located at the rear of the edge portion of the corresponding hole, the lower case 4 is also latched.

[0042] The lower case 4 forms the lower outer portion of the air cleaner 5, and carries a convex portion 4a and a convex portion 4f at the edge portion abutting the upper case 2. By these convex portions 4a and 4f engaging with the concave portion 2a and the attachment portion 2c of the upper case 2, respectively, the upper and lower cases 2 and 4 are firmly fixed to each other. Such engaged portions between the upper and lower cases 2 and 4 are each sealed by a seal member so that the air cleaner 5 remains airtight.

[0043] In the front portion of the lower case 4, an inner wall 4g extends toward inside of the air cleaner 5, and whereby an air intake port 4b is formed to guide the air coming from the air intake duct 3. The air cleaner 5 is divided into a front chamber 5a located before the inner wall 4g, and a main chamber 5b located behind the air intake port 4b. The air guided from the air intake port 4b flows into the main chamber 5b that functions mostly as an air intake chamber so that an airflow is produced therein.

[0044] Between the air intake port 4b and the main chamber 5b, the element 8 is laid across. An upper end 8a of the element 8 is firmly fixed to the upper end of the inner wall 4g by a bolt 12, and a lower end 8b thereof is engaged with a groove portion 4c of the lower case 4. Herein, the lower portion of the inner surface of the lower case 4 located behind the groove portion 4c, i.e., the inner surface of the main chamber 5b in which the airflow is produced is referred to as bottom surface.

[0045] Between a bottom surface front portion 4d and a bottom surface rear portion 4e of the main chamber 5b, provided is a circular through hole through which the air intake path 9 goes. As described in the foregoing, the fuel supply system of the present embodiment has four of the air intake path 9. It thus means that four through holes exist between the bottom surface front portion 4d and the bottom surface rear portion 4e. The lower case 4 is formed with small-diameter portions 4h that are each extended from around the corresponding through hole toward outside of the air cleaner 5, and their extended end portions are each changed in height

so that the corresponding through hole is reduced in diameter. The bottom surface front portion 4d and the bottom surface rear portion 4e are both formed to have a gentle down slope with respect to a horizontal plane H, directed to the through hole. In other words, the through hole is placed at the lowest position in the inner surface of the lower case 4.

[0046] The air intake port cover 6 has the lattice surface, for example, and is so laid as to cover the air intake port 4b that is formed to the lower case 4. With such a structure, the air directed from the air intake port 1 to the air exhaust duct 3 is guided to the air intake port 4b, and the air intake port 4b is prevented from receiving any foreign substances of a large diameter.

[0047] The element 8 removes, for air purification, any small dirt and impurities included in the air guided into the air intake port 4b, and forwards thus purified air to the main chamber 5b of the air cleaner 5.

[0048] The sub chamber cover 10 is laid across the hole of the upper case 2, and the front end thereof is firmly fixed to the attachment portion 2b of the upper case 2 by a bolt 14, and latched by a rear end 10d engaging with the convex portion of the attachment portion 2c. The engaged portions between the upper case 2 and the sub chamber cover 10 are also each sealed by a seal member so that the air cleaner 5 remains airtight. With such a structure that the upper case 2, the lower case 4, and the sub chamber cover 10 are securely fixed together, the air cleaner 5 is defined by contours.

[0049] To the inner surface of the sub chamber cover 10, a front end 10b and a rear end 10c of a support arm 10a are both securely fixed, and a sub chamber 10e is formed in the main chamber 5b of the air cleaner 5, enclosed by the sub chamber cover 10 and the support arm 10a. In this sub chamber 10e, the upstream injector unit 7 is placed. Herein, the attachment portions of the front and edge ends 10b and 10c of the support arm 10a are also each sealed by a seal member so that the main chamber 5b remains airtight. The sub chamber cover 10 is attached with an air intake temperature sensor 16 for measuring the air intake temperature in the main chamber 5b.

[0050] The upstream injector unit 7 includes an upstream injector 18, a fuel pipe 20, and a power supply harness 22.

[0051] The upstream injector 18 is supported by the support arm 10a attached to the sub chamber cover 10, and its components other than an injection port 18a are housed in the sub chamber 10e. There are four upstream injectors 18 due to a one-to-one relationship with the air intake path 9, and from the injection port 18a protruding from the sub chamber 10e into the main chamber 5b in the air cleaner 5, the fuel is injected into the main chamber 5b of the air cleaner 5.

[0052] The fuel pipe 20 is used to couple together the end portions of the four upstream injectors 18 located in the sub chamber 10e, and an end portion thereof is connected to a fuel tank that is not shown so that the fuel is supplied to the upstream injectors 18.

[0053] The power supply harness 22 is extended to the outside after going through the sub chamber cover 10, and is then connected to a control section that is not shown. The power supply harness 22 supplies power to the upstream injectors 18, and controls the fuel injection amount coming from the upstream injectors 18 and the injection timing thereby.

[0054] The air intake path 9 is provided with an air funnel 24, a throttle body 26, a joint member 36, and an air intake port 13f of the engine 13. Note that, in the present embodiment, these components are provided four of each because there are four air intake paths 9.

[0055] The air funnel 24 is made of an elastic body exemplified by rubber, and is attached to the small-diameter portion 4h of the through hole formed to the lower case 4. The air funnel 24 is covering the small-diameter portion 4h in its entirety, and the inner surface of an aperture 24a has a height difference 24b that is substantially equal to the thickness of the tube wall of the throttle body 26. The air funnel 24 is fit by the throttle body 26, from the downstream end to the height difference 24b. That is, the air funnel 24 serves as a connection member for connecting the throttle body 26 into the main chamber 5b of the air cleaner 5.

[0056] The aperture 24a of the air funnel 24 opening inside of the main chamber 5b has the same diameter as that of the through hole between the bottom surface front portion 4d and the bottom surface rear portion 4e. The inner surface of the aperture 24a of the air funnel 24 is so curved as to be continuous with both the bottom surface front portion 4d and the bottom surface rear portion 4e.

[0057] Herein, because the air funnel 24 is made of an elastic body, the air funnel 24 can be easily positioned in such a manner that the inner surface of the aperture 24a of the air funnel 24 is continuous with the bottom surface of the main chamber 5b. What is better, any dimension error observed in the through holes of the lower case 4, throttle body 26, or others can be absorbed.

[0058] Note here that the curved surface formed inside of the aperture 24a of the air funnel 24 is defined by radius of curvature depending on any desired flow rate coefficient. For example, to reduce energy loss with the flow rate coefficient of 0.99, the radius of curvature may be 0.33 times of the tube diameter of the throttle body 26.

[0059] The upstream end of the throttle body 26 is fit to the air funnel 24, and the downstream end thereof is fit to the joint member 36. The upstream end portion of the throttle body 26 is provided with a protrusion 26a, which is used to position the throttle body 26 for fitting to the air funnel 24. For such fitting, the height difference 24b provided to the inner surface of the aperture 24a of the air funnel 24 is also used. Here, because the air funnel 24 is covering the small-diameter portion 4h of the lower case 4, the throttle body 26 does not directly abut

the lower case 4 including the protrusion 26a. This thus prevents vibrations of the engine 13 from being transferred to the air cleaner 5 from the throttle body 26.

[0060] What is more, substantially at the center of the throttle body 26 in the airflow direction, a throttle valve 28 is provided for opening/closing the throttle body 26 by rotating about an axis. The throttle valve 28 is provided inside of each of the four throttle bodies 26. The throttle valves 28 inside of any adjacent throttle bodies 26 rotate about the same axis. On the downstream of the throttle valve 28, an attachment portion 26b is formed to firmly fix the downstream injector unit 11.

[0061] The joint member 36 is connecting together the throttle body 26, and the air intake port 13f of the engine 13.

[0062] The air intake port 13f of the engine 13 is opened/closed by an air intake valve 13b that is driven by an air intake cam 13a for opening/closing, and is linked to a combustion chamber 13c. The combustion chamber 13c is also linked with the air exhaust path 15, and an air exhaust port that is not shown in the air exhaust path 15 is opened/closed by an air exhaust valve 13e that is driven by the air exhaust cam 13d for opening/closing.

[0063] The downstream injector unit 11 is provided with a downstream injector 30, a fuel pipe 32, and a power supply harness 34.

[0064] The downstream injector 30 is supported by the attachment portion 26b of the throttle body 26, and its components other than the injection port 30a are protruding to outside of the air intake path 9. The downstream injector 30 is provided to each of the four air intake paths 9 for fuel injection from the injection port 30a into the corresponding air intake paths 9.

[0065] The fuel pipe 32 is used to couple together the end portions of the four downstream injectors 30, and an end portion thereof is connected to a fuel tank that is not shown so that the fuel is supplied to the downstream injectors 30.

[0066] The power supply harness 34 is connected to a control section that is not shown, and supplies power to the downstream injectors 30 so as to control the fuel injection amount coming from the downstream injectors 30 and the injection timing thereby.

[0067] FIG. 3 is an enlarged cross sectional view of the air funnel 24 of the present invention specifically in the vicinity of the aperture 24a.

[0068] As already described above, the bottom surface front portion 4d and the bottom surface rear portion 4e of the lower case 4 are both formed to have a down slope toward the through hole with which the air funnel 24 is engaged. That is, as shown in FIG. 3, the bottom surface front portion 4d has a down slope α with respect to the horizontal plane H toward the aperture 24a of the air funnel 24, and the bottom surface rear portion 4e has a down slope β with respect to the horizontal plane H toward the aperture 24a. These down slopes α and β are both angled at 45 degrees or less, and preferably, these down slopes α and β are both angled gently about 30 degrees or less.

[0069] At the lower ends of the bottom surface front portion 4d and the bottom surface rear portion 4e having such down slopes α and β, respectively, the aperture 24a of the air funnel 24 is placed, and the inner surface of the aperture 24a of the air funnel 24 is continuous with both the bottom surface front portion 4d and the bottom surface rear portion 4e. That is, the aperture 24a of the air funnel 24 is located on the plane including the lower ends of the bottom surface front portion 4d and the bottom surface rear portion 4e, and the aperture 24a is not protruding into the main chamber 5b of the air cleaner 5.

[0070] Note that, in the present embodiment, the bottom surface front portion 4d and the bottom surface rear portion 4e are assumed as sloped down toward the aperture 24a of the air funnel 24. The present invention is not restrictive to such a structure, and the bottom surface front portion 4d and the bottom surface rear portion 4e may be horizontal.

[0071] Further, as shown in FIG. 4, the bottom surface front portion 4d and the bottom surface rear portion 4e may not be flat but curved. If the bottom surface front portion 4d and the bottom surface rear portion 4e are both curved, the tangent at the lower end linked to the aperture 24a may be horizontal or sloped down toward the aperture 24a.

[0072] No matter if the bottom surface front portion 4d and the bottom surface rear portion 4e are flat or curved, the inner surface of the aperture 24a of the air funnel 24 is formed continuous with the bottom surface front portion 4d and the bottom surface rear portion 4e, and the aperture 24a is not protruding into the main chamber 5b.

[0073] Described now is the shape of the bottom surface of the main chamber 5b in the air cleaner 5.

[0074] FIG. 5 is a plan view of the lower case 4 of the air cleaner 5 of the present embodiment, viewed from the direction of an arrow A of FIG. 2.

[0075] As described in the foregoing, the bottom surface front portion 4d and the bottom surface rear portion 4e are sloped down toward the aperture 24a of the air funnel 24. A bottom surface center portion 4i formed between any two adjacent apertures 24a is also sloped down toward the aperture 24a locating closer.

[0076] Accordingly, any arbitrary line segment connecting the two adjacent apertures 24a on the bottom surface center portion 4i carries the highest apex. The edge line extending from the rear end of the lower case 4 toward the air intake port 4b as a collection of such apexes is thus formed at the position indicated by a broken line of FIG. 5, for example. Here, as indicated by a chain double-dashed line in FIG. 5, the front part of the edge line may be extended toward the center of the air intake port 4b.

[0077] Because the bottom surface center portion 4i is formed with the edge line as such, the cross section view cut along the line I-I of FIG. 5 looks like the one

shown in FIG. 6, for example. By referring to FIG. 6, the bottom surface center portion 4i is formed continuous with the inner surface of the aperture 24a of the air funnel 24. Such a structure forms a plane continuous all with the bottom surface front portion 4d, the bottom surface rear portion 4e, and the bottom surface center portion 4i enclosing the aperture 24a of the air funnel 24, and the inner surface of the aperture 24a of the air funnel 24, whereby the portion in the vicinity of the aperture 24a of the air funnel 24 is formed to look like a funnel.

[0078] Here, the bottom surface front portion 4d, the bottom surface rear portion 4e, and the bottom surface center portion 4i are all gently sloped down at an angle of 45 degrees or less with respect to the horizontal plane, preferably gently at an angle of 30 degrees or less with respect to the horizontal plane. This is because there needs to increase the change of cross sectional area between that of the throttle body 26 and that of the upper part of the aperture 24a. The reason therefor is described below.

[0079] That is, in the stroke of the engine 13 for air intake, the air intake valve 13b is first opened. At this time, at the area in the vicinity of the air intake port 13f that is located at the most downstream of the air intake path 9, generated are shock waves that are to be propagated to the upstream of the air intake path 9 at a speed faster than sound. After generation of such shock waves, the air and fuel start flowing into the combustion chamber 13c. Therefore, the area in the vicinity of the air intake port 13f will be under vacuum, and pulsing waves being compressional waves of the air are transferred from downstream to upstream in the air intake path 9.

[0080] The shock waves first reach the aperture 24a at a speed faster than sound, and then are propagated into the main chamber 5b of the air cleaner 5. On the other hand, the pulsing waves reach the aperture 24a with a delay from the shock waves, and then again go through the air intake path 9 from upstream to downstream. This is because their propagation direction is reversed due to the open end of the aperture 24a. Utilizing such pulsing waves with the reversed propagation direction, the air and fuel are directed into the combustion chamber 13c of the engine 13 so that the engine 13 can be improved in filling efficiency.

[0081] For determining whether the aperture 24a has the open end or not, referred to is the change of cross sectional area between that of the throttle body 26 and that of the upper part of the aperture 24a. When the change of cross sectional area is larger than a predetermined value, a determination is made that the end is open.

[0082] That is, if the bottom surface front portion 4d, the bottom surface rear portion 4e, and the bottom surface center portion 4i are all steeply sloped down, the cross section shows no abrupt change from the throttle body 26 to the upper part of the aperture 24a. With this being the case, the aperture 24a has no open end, and thus the propagation direction of the pulsing waves is not reversed. This is the reason why the bottom surface front portion 4d, the bottom surface rear portion 4e, and the bottom surface center portion 4i are all gently sloped down, or may be horizontal.

[0083] As such, because the bottom surface front portion 4d, the bottom surface rear portion 4e, and the bottom surface center portion 4i are all made horizontal or gently sloped down toward the aperture 24a, the aperture 24a opens at the lowest position in the inner surface of the main chamber 5b.

[0084] FIG. 7 is a perspective view of the lower case 4, viewed from the upper rear left. In the drawing, neither the air intake port cover 6 nor the element 8 is shown.

[0085] As shown in FIG. 7, the bottom surface front portion 4d, the bottom surface rear portion 4e, and the bottom surface center portion 4i are all continuous with the inner surface of the aperture 24a of the air funnel 24, and the inner surface of the aperture 24a of the air funnel 24 is one piece with the bottom surface of the lower case 4.

[0086] At the center of the bottom surface center portion 4i in the direction across the vehicle, an edge line is extending from the rear end of the lower case 4 toward the air intake port 4b. In FIG. 7, an edge line is formed at the center of the bottom surface center portion 4i. This is not restrictive, and the edge line may be laterally biased or bent at some midpoint instead of being formed at the center of the bottom surface center portion 4i. Further, the edge line is not necessarily formed distinctly, and the bottom surface center portion 4i may have the shape of a saddle. In short, it will do as long as the edge line as a collection of the highest points on the bottom surface center portion 4i between any two adjacent apertures 24a is extending from the rear end of the lower case 4 toward the air intake port 4b.

[0087] Described next is the built-in structure of the air funnel 24 to the lower case 4.

[0088] By referring to FIG. 5 again, a bolt 38 is used to clamp and fix together the bottom surface center portion 4i of the lower case 4, and the throttle body 26 forming any two adjacent air intake paths 9. In FIG. 5, the bolt 38 performs clamping and fixation at a midpoint of the line segment connecting the centers of the two adjacent apertures 24a. Alternatively, two points before and after the midpoint may be clamped for fixation.

[0089] In the area in the vicinity of the bolt 38 of the air funnel 24, a protrusion 24c is formed. The protrusion 24c is protruding in such a manner as to cover the head portion of the bolt 38.

[0090] FIG. 8 is a cross sectional view cut along the line II-II of FIG. 5 in the present embodiment.

[0091] Upon building in the air intake path 9 to the air cleaner 5 of the present embodiment, first of all, the air funnel 24 is attached to the small-diameter portion 4h that is formed to the through hole on the bottom surface of the lower case 4. The air funnel 24 is so attached that the aperture 24a does not protrude into the main cham-

ber 5b, and the inner surface of the aperture is continuous with the bottom surface front portion 4d, the bottom surface rear portion 4e, and the bottom surface center portion 4i. The air funnel 24 is made of an elastic body such as rubber, and thus can be shaped as above with ease.

[0092] Thereafter, the throttle body 26 having the shape of two tubular members coupled next to each other is fit to the air funnel 24 from the downstream end. At this time, the upstream end of the throttle body 26 abuts the height difference 24b formed to the inner surface of the aperture 24a of the air funnel 24, and the protrusion 26a of the throttle body 26 abuts the downstream end of the air funnel 24. In this manner, the air funnel 24 and the throttle body 26 are both defined by position.

[0093] On the other hand, a bolt hole formed to the bottom surface center portion 4i of the lower case 4 is engaged with a rubber grommet 40. The bolt 38 goes through the center hole of the rubber grommet 40, and is engaged to the attachment portion 26c of the throttle body 26.

[0094] With such a structure, the head portion of the bolt 38 and the attachment portion 26c of the throttle body 26 sandwich, for fixation, the rubber grommet 40, the bottom surface center portion 4i, and the air funnel 24. This thus allows to firmly fix the air cleaner 5 and the air intake path 9 with certainty with the fewer number of components, and the components protruding into the main chamber 5b of the air cleaner 5 can be reduced in number. Accordingly, this enables easy assembly, and achieves better engine performance with airflow turbulence suppressed in the main chamber 5b.

[0095] What is more, with the structure that the air funnel 24 is firmly fixed between the bottom surface center portion 4i of the lower case 4 and the throttle body 26, the air intake path 9 can be shortened in length compared with the case of fixing together the air funnel 24 and the throttle body 26 using a band for wrapping therearound. This thus favorably leads to system downsizing.

[0096] Further, the throttle body 26 and the bolt 38 are not directly but indirectly abutting the lower case 4 via the air funnel 24 and the rubber grommet 40. This thus prevents vibrations of the engine 13 from being transferred to the lower case 4 from the throttle body 26 and the bolt 38. Accordingly, even if the upstream injector unit 7 is supported by the air cleaner 5, vibration transfer to the upstream injector unit 7 is reduced, thereby achieving the stable fuel supply.

[0097] Still further, because the protrusion 24c of the air funnel 24 is covering the head portion of the bolt 38, even if the bolt 38 is loosened and comes off due to vibrations, the protrusion 24c stops the bolt 38 not to move. With such a structure, the bolt 38 does not find its way from the aperture 24a of the air funnel 24 into the engine 13.

[0098] Described next is the fuel supply operation of the fuel supply system structured as above.

[0099] The air captured by the air intake port 1 is guided to the air intake port 4b of the air cleaner 5 after going through the air intake duct 3. At this time, the air intake port cover 6 serves to stop large-particle foreign substances not to enter the air intake port 4b. This structure prevents damage to the inner wall 4g and the element 8 both exposed to the air intake port 4b.

[0100] The air guided to the air intake port 4b is then purified by the element 8 removing small dirt or impurities, and thus purified air then flows into the main chamber 5b of the air cleaner 5. After flowing in the main chamber 5b, the air flows toward the aperture 24a of the air funnel 24. As such, produced is an airflow going through the main chamber 5b, the air funnel 24, the throttle body 26, the joint member 36, and the air intake port 13f.

[0101] On the other hand, in the stroke of the engine 13 for air intake, the intake cam 13a opens the air intake valve 13b. At the time point when the air intake valve 13b is opened, the upstream and downstream injectors 18 and 30 are both controlled, for fuel injection, by a control section that is not shown. That is, the upstream injector 18 injects the fuel into the main chamber 5b, and the downstream injector 30 injects the fuel into the air intake path 9.

[0102] The control section that is not shown determines the fuel amount and timing for fuel injection based on the rotation speed of the engine 13, the degree of opening of the throttle valve 28, the pressure in the air intake path 9, and others. The control section then supplies power to both the upstream and downstream injectors 18 and 30 through the power supply harnesses 22 and 34 so that the fuel is injected.

[0103] To be specific, the control section that is not shown detects the point in time when the air intake stroke is started (i.e., the timing when the air intake valve 13b opens) by a sensor for detecting the cycle of the engine 13, for example. After a lapse of some desired set time from the point in time, the control section has the upstream and downstream injectors 18 and 30 injected the fuel.

[0104] At this time, as described above, when the air intake stroke is started, shock waves are generated to be propagated from the air intake path 9 to the main chamber 5b. By making the shock waves collide with the fuel coming from the upstream and downstream injectors 18 and 30 through adjustment of the above-mentioned set time, the fuel will scatter and thus the fuel atomization is facilitated to a greater extent. Especially after the shock waves propagated into the main chamber 5b, colliding the shock waves with the fuel injected from the upstream injector 18 will lead to the better volumetric efficiency. This is because such a collision results in fuel splash in the wide space of the main chamber 5b, thereby achieving fuel atomization in an efficient manner.

[0105] Moreover, with fuel injection from the upstream and downstream injectors 18 and 30 at least when the air intake process is started (i.e., the set time is 0), for example, the injected fuel collides with the shock waves

in the air intake path 9 or the main chamber 5b. The shock waves are those generated when the air intake process is started and the air intake valve 13b opens. Therefore, there is no more need to count the set time using a timer or others, and easy control can cause a collision between the shock waves and the fuel.

[0106] The fuel injected from the upstream injector 18 is atomized in the main chamber 5b, and also flows from the aperture 24a of the air funnel 24 to the air intake path 9 by the airflow produced in the main chamber 5b. At this time, the fuel partially splashes (bubbles) over the bottom surface front portion 4d, the bottom surface rear portion 4e, and the bottom surface center portion 4i in the main chamber 5b due to airflow turbulence or others. In the present embodiment, however, the bubbled-over fuel will flow from the aperture 24a of the air funnel 24 to the air intake path 9 due to the structure that all of the bottom surface front portion 4d, the bottom surface rear portion 4e, and the bottom surface center portion 4i are formed continuous with the inner surface of the aperture 24a of the air funnel 24. A description will be made later of this matter.

[0107] Note that, in the present embodiment, the injection port 18a of the upstream injector 18 is oriented toward the aperture 24a of the air funnel 24, and thus the fuel is directed from the injection port 18a to the aperture 24a. With such a structure, compared with a case where the upstream injector 18 injects the fuel toward the bottom surface front portion 4d in the main chamber 5b or others, the fuel does not bubble over that much, and the air-fuel ratio is almost the same among the four air intake paths 9.

[0108] For example, even if the upstream injector 18 injects the fuel toward the bottom surface front portion 4d in the main chamber 5b, in the present invention, the bubbled-over fuel will flow from the aperture 24a of the air funnel 24 into the air intake paths 9 due to the structure that all of the bottom surface front portion 4d, the bottom surface rear portion 4e, and the bottom surface center portion 4i are formed continuous with the inner surface of the aperture 24a of the air funnel 24.

[0109] On the other hand, by the pulsing waves moving upstream and downstream in the air intake paths 9, the fuel coming from the upstream injector 18 into the air intake paths 9 is blown back to the main chamber 5b of the air cleaner 5 from the aperture 24a of the air funnel 24. Thus blown-back fuel splashes over the bottom surface front portion 4d, the bottom surface rear portion 4e, and the bottom surface center portion 4i in the main chamber 5b. In the present embodiment, however, the blown-back fuel will flow into the air intake paths 9 from the aperture 24a of the air funnel 24 due to the structure that all of the bottom surface front portion 4d, the bottom surface rear portion 4e, and the bottom surface center portion 4i are formed continuous with the inner surface of the aperture 24a of the air funnel 24. A description will be made later of this matter.

[0110] As such, the fuel bubbled over or blown back to the bottom surface front portion 4d, the bottom surface rear portion 4e, and the bottom surface center portion 4i in the main chamber 5b flows into the air intake paths 9 without clogging. This thus eliminates the need to consider a possibility that the fuel coming from the upstream injector 18 splashes over the bottom surface of the main chamber 5b. Therefore, there is no more need to control the amount of fuel to be injected from the upstream injector 18 to the main chamber 5b, and thus the fuel can be sufficiently supplied to the engine 13.

[0111] When the air intake cam 13a opens the air intake valve 13b under such circumstances as described above, the combustion chamber 13c is provided with enough amount of fuel. In the combustion chamber 13c, the gas mixture of air and fuel is compressed in the compression stroke, and thus compressed gas mixture explodes in the combustion stroke so that the power is generated.

[0112] In the air exhaust stroke subsequent to the combustion stroke, the air exhaust cam 13d opens the air exhaust valve 13e, and the exhaust gas as a result of explosion is exhausted to the air exhaust path 15, and then exhausted outside from the exhaust muffler 17. After this exhaustion stroke is completed, the air intake stroke follows, and the above-described operation is repeated.

[0113] In the below, it will be described how the fuel splashed over the bottom surface front portion 4d, the bottom surface rear portion 4e, and the bottom surface center portion 4i in the air intake stroke will flow into the air intake paths 9.

[0114] In the present embodiment, all of the bottom surface front portion 4d, the bottom surface rear portion 4e, and the bottom surface center portion 4i are formed continuous with the inner surface of the aperture of the aperture 24a of the air funnel 24. With such a structure, no air stagnation is observed in the vicinity of the bottom surface front portion 4d, the bottom surface rear portion 4e, and the bottom surface center portion 4i, and the generated airflow has the flow velocity of a certain level or higher. Therefore, the easy-to-vaporize fuel such as gasoline is vaporized by the airflow of a close range immediately after splashing over the bottom surface front portion 4d, the bottom surface rear portion 4e, and the bottom surface center portion 4i, and then flows into the air intake paths 9 from the aperture 24a of the air funnel 24 together with the fuel atomized in the main chamber 5b.

[0115] At this time, the faster the flow velocity of the airflow in the main chamber 5b, the easier the fuel splashed over the bottom surface front portion 4d, the bottom surface rear portion 4e, and the bottom surface center portion 4i will vaporize. In the present embodiment, the air intake port 1 is provided frontward of the vehicle as shown in FIG. 1, and the air cleaner 5 is provided behind the air intake port 1 in the vehicle. Accordingly, when the vehicle is moving, the airflow in the air

intake duct 3 picks up momentum by the running wind flowing from front to rear, and thus more air comes from the air intake port 4b of the air cleaner 5.

[0116] Also in the air cleaner 5, the aperture 24a of the air funnel 24 serving as an air discharge port is provided behind the air intake port 4b. That is, the air flow path is so structured as to entirely direct from the front toward rear, and thus when the vehicle of FIG. 1 moves, the airflow in the main chamber 5b of the air cleaner 5 picks up momentum by the running wind generated by the moving-forward vehicle, thereby increasing the flow velocity. Accordingly, the fuel splashed over the bottom surface front portion 4d, the bottom surface rear portion 4e, and the bottom surface center portion 4i is vaporized with more ease.

[0117] Additionally, in order to capture more air in the main chamber 5b, the element 8 serving as air intake resistance is generally large in area. Specifically, the element 8 has almost the same area as the cross sectional area of the air cleaner 5 cut along the vertical direction of the airflow (refer to FIG. 2). Therefore, the air having passed through the element 8 spreads over the main chamber 5b and becomes an airflow, and the resulting airflow flows into the aperture 24a of the air funnel 24. This is the reason why no air stagnation is observed in the vicinity of the entire bottom surface 4d, the bottom surface rear portion 4e, and the bottom surface center portion 4i, whereby the splashed fuel can be vaporized with more ease.

[0118] When the bottom surface front portion 4d, the bottom surface rear portion 4e, and the bottom surface center portion 4i are all sloped down, the fuel splashed over the bottom surface front portion 4d, the bottom surface rear portion 4e, and the bottom surface center portion 4i is not only vaporized by the airflow but also flows into the aperture 24a of the air funnel 24 due to gravity. Especially when the large amount of fuel is splashed, the fuel failed to vaporize will drip into the aperture 24a as fuel drops.

[0119] When the air intake stroke is started, there may be a case where the air exhaust stroke in the previous cycle is still under way (i.e., the air exhaust valve 13e and the air intake valve 13b are open simultaneously). With this being the case, flames may flow back from the combustion chamber 13c to the air intake paths 9.

[0120] Although thus flowed-back flames reach the main chamber 5b of the air cleaner 5, the air exhaust valve 13e is to be closed immediately. As a result, the fuel splashed over the bottom surface front portion 4d, the bottom surface rear portion 4e, and the bottom surface center portion 4i goes through the air intake paths 9 again while burning due to the flames, and then is sucked into the combustion chamber 13c.

[0121] As such, the fuel clogging is suppressed on the bottom surface front portion 4d, the bottom surface rear portion 4e, and the bottom surface center portion 4i, and there is no more need to give a consideration to fuel splash over the bottom surface front portion 4d, the bottom surface rear portion 4e, and the bottom surface center portion 4i, and the fuel can be sufficiently injected from the upstream injector 18. This means that the fuel can be sufficiently injected even when the engine 13 is at the high speed and high load operation so that the engine performance can be improved.

[0122] As described in the foregoing, according to the present embodiment, the fuel from the upstream injector splashed over the bottom surface of the air cleaner does not clog thanks to the inner surface of the aperture of the air funnel that is formed continuous with the bottom surface of the air cleaner. Accordingly, there is no more need to consider a possibility that the fuel coming from the upstream injector may bubble over, and thus the upstream injector and the apertures of the air intake paths are not necessarily placed closer, or the amount of fuel coming from the upstream injector is not necessarily controlled. As a result, the fuel may be injected from the upstream injector into the air cleaner to facilitate fuel atomization, and the engine performance can be improved with sufficient fuel supply when the engine is at the high speed and high load operation.

[0123] Note that, in the present embodiment, described is a case where the bottom surface of the main chamber 5b of the air cleaner 5 is formed continuous with the inner surface of the aperture 24a of the air funnel 24. Alternatively, the through hole formed to the bottom surface of the main chamber 5b of the air cleaner 5 may be formed in the shape of the air funnel 24 of the present embodiment. If this is the case, the area downstream of the through hole formed at the bottom surface will function as the air intake path 9.

[0124] Further, in the present embodiment, described is the structure that the entire edge of the aperture 24a of the air funnel 24 is formed smoothly continuous with the bottom surface of the main chamber 5b. This is not restrictive, and only a part of the edge of the aperture 24a may be formed smoothly continuous with the bottom surface of the main chamber 5b. That is, as a possible exemplary structure, only the bottom surface front portion 4d and the bottom surface rear portion 4e may be formed continuous with the inner surface of the aperture 24a, and the bottom surface center portion 4i may not be continuous with the inner surface of the aperture 24a. With this being the case, the bottom surface may be so formed that its end portion abutting the aperture 24a of the bottom surface front portion 4d or that of the bottom surface rear portion 4e comes at the lowest ; sition.

[0125] Still further, in the present embodiment, scribed is a case where a sub chamber is provide; the upper part of the aperture 24a of the air funnel for housing the upstream injector unit 7. As an alternative structure, for the purpose of fuel atomization with more ease, as exemplarily shown in FIG. 9, the aperture 24a of the air funnel 24 may be placed away from an upstream injector 18'. Even if the aperture 24a of the air funnel 24 may be placed away from the upstream injec-

tor 18' as such, thanks to such a structure of the present invention that the inner surface of the aperture 24a of the air funnel 24 is formed continuous with the bottom surface of the air cleaner 5, there is no need to consider a possibility that the fuel clogging may occur because the fuel coming from the upstream injector 18' bubbles over the bottom surface of the air cleaner 5.

(Second Embodiment)

[0126] A second embodiment of the present invention is characterized in that the fuel coming from an upstream injector is prevented from bubbling over with such a structure that the apertures of a plurality of air intake paths are partially protruded into an air cleaner.

[0127] The overall structure of a vehicle and a fuel supply system of the present embodiment is similar to that of the first embodiment, and thus is not described again. In the present embodiment, compared with the first embodiment, differences are observed in the cross sectional views cut along the lines I-I and II-II, respectively, in FIG. 5.

[0128] FIG. 10 is a cross sectional view cut along the line II-II in FIG. 5 according to the present embodiment. In the drawing, any components similar to those in FIG. 8 are provided with the same reference numerals, and not described again.

[0129] As shown in the drawing, in the present embodiment, two of the air intake paths 9 located at the center are protruding into the main chamber of the air cleaner 5. As to these two air intake paths 9, an air funnel 42 is attached as an alternative to the air funnel 24 at the upstream end of the throttle body 26.

[0130] The air funnel 42 is made of an elastic body exemplified by rubber, and attached to the small-diameter portion 4h of the through hole formed to the lower case 4. Unlike in the first embodiment, an aperture 42a of the air funnel 42 is protruding into the main chamber 5b of the air cleaner 5, and placed in the vicinity of the injection port 18a of the upstream injector 18.

[0131] With such a structure, the fuel coming from two of the four upstream injectors 18 located at the center is directly impinged against the inner surface of the aperture 42a of the air funnel 42, and thus the fuel is prevented from bubbling outside.

[0132] The tube wall located on the center side of the air cleaner 5 of the air funnel 42 is through with a linear hole 42b in such a manner that the inner surface of the aperture 42a of the air funnel 42 is continuous with the bottom surface center portion 4i. Moreover, a tube wall 42c in the vicinity of the bolt 38 of the air funnel 42 is formed thick to form the aperture 42a, and at the same time, to function similarly to the protrusion 24c in the first embodiment. That is, the tube wall 42c is covering the head portion of the bolt 38 so as to stop the bolt 38 not to move even if it comes off, and prevents bolt 38 from finding its way from the aperture 24a of the air funnel 24 into the engine 13.

[0133] FIG. 11 is a cross sectional view cut along the line I-I in FIG. 5 according to the present embodiment. In the drawing, any components similar to those in FIG. 6 are provided with the same reference numerals, and not described again.

[0134] In the drawing, unlike the bottom surface center portion 4i in the first embodiment, a bottom surface center portion 4j formed between two adjacent air funnels 42 and 24 is formed with no edge line. Moreover, the bottom surface center portion 4j is sloped down toward the aperture 24a of the air funnel 24 that is not protruding into the main chamber 5b, and is formed continuous with the inner surface of the aperture 24a of the air funnel 24.

[0135] On the other hand, similarly to the first embodiment, the bottom surface center portion 4i formed between any two adjacent air funnels 42 is formed with an edge line. The bottom surface of the main chamber 5b including the bottom surface center portions 4i and 4j is curved with the edge line in the direction across the vehicle.

[0136] In the present embodiment, two of the air intake paths 9 located at the center are made to protrude into the main chamber 5b, and the aperture 42a is provided in the vicinity of the injection port 18a of the upstream injector 18. This structure prevents the fuel from bubbling over from the two upstream injectors 18 at the center, but the fuel coming from the two upstream injectors 18 at both ends bubbles over similarly to the first embodiment.

[0137] Even if the fuel is bubbled up, however, because the bottom surface center portion 4j is sloped down toward the aperture 24a of the air funnel 24 and is formed continuous with the inner surface of the aperture 24a of the air funnel 24, the fuel will be vaporized or liquidized by the airflow along the bottom surface front portion 4d, the bottom surface rear portion 4e, and the bottom surface center portion 4j before flowing into the aperture 24a. Therefore, no air stagnation occurs.

[0138] If the fuel splashes over the bottom surface center portion 4i by blowing back from the two air intake paths 9 at the center due to the pulsing waves, or bubbling over the two upstream injectors 18 at the center even of a little amount, the fuel flows into the air intake paths 9 from the linear hole 42b facing the bottom surface center portion 4i of the air funnel 42. Moreover, because the bottom surface of the main chamber 5b is curved, the fuel splashed over the bottom surface center portion 4i flows over the bottom surface center portion 4j after detouring the air funnel 42, and then flows into the air intake paths 9 from the aperture 24a of the air funnel 24.

[0139] Accordingly, even if the two apertures 42a of the air funnels 42 at the center are protruding into the main chamber 5b, and the inner surface of the aperture 42a of the air funnel 42 is not continuous with the bottom surface of the main chamber 5b, the fuel bubbled over the bottom surface of the main chamber 5b from the up-

stream injector 18 never clogs.

[0140] FIG. 12 shows an exemplary case where the bottom surface of the main chamber 5b is made different in height, and the two air intake paths 9 at the center are protruding into the main chamber 5b.

[0141] In the drawing, the bottom surface of the main chamber 5b is provided with a height difference 4k, and the bottom surface of the center portion of the main chamber 5b is formed at the higher position than the bottom surface of the end parts. The bottom surface around the air intake paths 9 is formed continuous with the inner surface of the aperture 24a of the air funnel 24.

[0142] With such a structure, the apertures 24a of the two air funnels 24 at the center are formed in the vicinity of the upstream injector 18, and thus the fuel can be prevented from bubbling over from the upstream injector 18. What is more, the fuel splashed over the bottom surface of the main chamber 5b never clogs.

[0143] As described above, according to the present embodiment, the apertures of a plurality of air intake paths are partially protruded into the main chamber of the air cleaner to be located in the vicinity of the upstream injector, and the apertures of the remaining air intake paths are so formed that their inner surfaces are continuous with the bottom surface of the air cleaner. This favorably prevents the fuel from bubbling over from the upstream injector, and even if the fuel splashes over the bottom surface of the air cleaner as a result of bubbling over or blowing back, the fuel never clogs. Accordingly, the upstream injector injects the fuel into the air cleaner so that the fuel atomization is facilitated, and the engine performance can be improved with the sufficient fuel supply when the engine is at the high speed and high load operation.

[0144] Note that, in the present embodiment, exemplified is the structure that the two air intake paths at the center are protruding into the main chamber of the air cleaner. This is not restrictive, and even if the two air intake paths at ends or any one of the air intake paths are/is protruding into the air cleaner, the bottom surface of the main chamber or the air funnel may be changed in shape based on the same concept.

[0145] As describe above, air being introduced from the outside through an air intake port 1 is led to the air cleaner 5 where an air intake duct 3 entering the air cleaner 5, in particular the intake chamber thereof, via an air inlet opening. This air inlet opening may be configured so to be a port such an opening or a hole connecting an inside of the air intake chamber 5a to an outside thereof: the outside being either free environment, for example, or, according to an embodiment, the air intake duct 3.

[0146] According to an embodiment as also described above, the air inlet opening of the intake chamber 5a may also comprise an air guide portion 4b for guiding the air entering the air intake chamber 5b from the outside further inwardly, thereafter. In other words, the air inlet opening may be understood also as being or comprising a channel or tube-like structure which forms a path for guiding the air after it has entered the air intake chamber 5b. Preferably, the air guide portion leads to a filter element being provided within the air intake chamber 5b.

[0147] The air guide portion 4b of the air inlet opening may also be configured to be arranged after or downstream of the filter element 8, if desired. An inner surface of the air intake chamber 5b may also be considered as air guide portion or part thereof.

[0148] As further described above, according to an embodiment, an upstream injector 18 is provided upstream of an aperture 24a of an air intake path 9 connecting an interior of the air intake chamber 5b with an engine 13. The upstream injector 18 which is part of an upstream injector unit 7 may be placed fully within the interior of the air intake chamber 5b according to one embodiment, may be provided to be located completely outside of the intake chamber according to another embodiment or may be located to be partially provided inside and/or partially outside of the air intake chamber according to a further embodiment.

[0149] In any embodiment, the air intake chamber may comprise a further opening through which the first injector 18 is placeable at least partially within the intake chamber or through which the injector 18, if being placed outside of the intake chamber, injects fuel into the intake chamber, in particular into an air stream provided therein.

[0150] It may be further desirable to place a second injector 30, being part of a downstream injector unit 11 downstream of the aperture 24a or outside thereof so to introduce fuel into the air intake path 9 downstream of the aperture 24. It is further possible to place the first injector 18 and the second injector 11 inside the interior of the air intake chamber 5, the one being provided downstream of the other or vice versa.

[0151] It is also possible that the second injector 30 which preferably is placed in the air intake path 9 is provided downstream of a throttle valve 28, which is preferably provided in the air intake path 9, too. However, according to a further aspect of the invention and/or a preferred embodiment, a fuel supply system may be provided having two fuel injectors one being located upstream of the other fuel injector, wherein the fuel supply system is free from the provision of a throttle valve. Alternatively, at least the portion forming the air path or the entire air path between the two injectors may be provided free of a throttle valve.

[0152] In the described embodiment, wherein the first injector injects fuel into an interior of the air intake chamber 5b upstream of the aperture 24a leading to the air intake path 9, the second injector may be provided to be positioned so to inject fuel into the air intake path 9 downstream of the aperture 24a wherein, according to a first embodiment, a throttle valve 28 is provided in the air intake path 9, in particular between the aperture 24a and the downstream injector unit 11 and/or wherein, ac-

cording to another embodiment, the air intake path 9 is either completely free of a throttle valve 28 or at least does not comprise any throttle valve between the aperture and the downstream injector unit.

[0153] Such an embodiment wherein the air intake path 9 is free from a throttle valve, meaning that no throttle valve is provided therein, has the advantage that any fuel injected from the upstream injector through the aperture 24a into the air intake path 9 can freely continue its flow together with the air into the engine 13 without being hindered by getting stuck to any throttle valve to thereby influence the timing and the flow of the fuel such that engine performance can be improved and fuel injection can be performed and controlled more finely.

[0154] Of course, in the various above-described embodiments with or without throttle valve are freely combinable with any features of the before-described embodiments, in particular regarding the provision of various features such as in particular the configuration of the aperture and the shape of the interior of the air intake chamber at its lower end where the aperture 24a is provided. Herein, the configuration is preferably as described in connection with the various pictured embodiments.

[0155] As is disclosed in this specification, a preferred embodiment of a fuel supply system is provided, including: an air intake chamber is provided including an air guide portion for guiding air; an air intake path including an aperture that opens toward inside of the air intake chamber for guiding the air in the air intake chamber from the aperture to an engine; and an injector provided inside of the air intake chamber for injecting fuel between the air guide portion and the aperture. In the air intake path, an inner surface of the aperture is structured continuous to a bottom surface of the air intake chamber.

[0156] With such a structure, the fuel splashed over the bottom surface of the air intake chamber does not clog but flows into the air intake path because the inner surface of the aperture of the air intake path serving to direct the air in the air intake chamber to the engine is formed continuous with the bottom surface of the air intake chamber. Accordingly, in order to achieve the sufficient amount of fuel coming from the injector, there is no more need to control the amount of fuel to be injected from the injector, and to place the injector closer to the aperture of the air intake path. What is more, because the fuel is injected between the air guide portion for guiding the air into the air intake chamber and the aperture of the air intake path, the fuel can be better atomized with the air intake chamber efficiently used in space. This thus favorably facilitates atomization of fuel to be injected from the injector, and the engine performance can be improved with sufficient fuel supply when an engine is at the high speed and high load operation.

[0157] According to a preferred embodiment, the fuel supply system has the air intake chamber whose bottom surface is sloped down toward the outer edge of the aperture of the air intake path.

[0158] With such a structure, the bottom surface of the air intake chamber is sloped down toward the outer edge of the aperture of the air intake path. Accordingly, when the large amount of fuel is splashed over the bottom surface of the air intake chamber, the fuel will drip into the air intake path as fuel drops, whereby the fuel can be prevented from clogging on the bottom surface with more certainty.

[0159] Preferably, the fuel supply system has the air intake chamber whose bottom surface is sloped at an angle α, β of preferably 45 degrees or less with respect to a horizontal plane.

[0160] Preferably, the angle ranges between 1° to 44°, more preferably an upper range limit is 40°, 35°, 30°, 25°, 20° or less. Also, preferably a lower range limit is 5°, 10°, 15°, 20°, 25° or larger. By choice of a specific range, the best fuel transport performance can be achieved for the desired type of Supply System, Engine and/or Vehicle.

[0161] With such a structure, the bottom surface of the air intake chamber is sloped down preferably at the angle of 45 degrees or less with respect to the horizontal plane. Thus, when the large amount of fuel is splashed over the bottom surface of the air intake chamber, the fuel will drip into the air intake path as fuel drops. Moreover, the change of cross sectional area between the air intake path and the upper part of the aperture of the air intake path is increased, and the aperture of the air intake path will be an open end of the pulsing waves to be generated in the air intake path. This thus reverses the propagation direction of the pulsing waves at the aperture, and thus more air and fuel can go to the engine. Moreover, the engine performance can be improved to a greater degree.

[0162] Preferably, the fuel supply system has the air intake chamber having an airflow produced by the air guided from the air guide portion along the bottom surface toward the aperture.

[0163] With such a structure, the air entered from the air guide portion produces an airflow flowing toward the aperture along the bottom surface. The fuel splashed over the bottom surface of the air intake chamber is thus vaporized without clogging, and flows from the aperture into the air intake path. Accordingly, even if the bottom surface of the air intake chamber is not sloped down, the fuel is prevented from clogging on the bottom surface with more certainty.

[0164] Preferably, the fuel supply system has the air intake path including: a connection member that forms the aperture, and goes through the bottom surface of the air intake chamber from inside of the air intake chamber toward outside; and a tubular member for establishing a connection with the connection member from the outside of the air intake chamber.

[0165] With such a structure, from outside of the air intake chamber, the tubular member is coupled to the connection member that externally goes through the

bottom surface of the air intake chamber from the inside of the air intake chamber. Such coupling increases assembly characteristics, and any components already in the market such as throttle body can be used as a tubular member.

[0166] Preferably, the fuel supply system has the connection member made of an elastic material.

[0167] With such a structure, because the connection member is made of an elastic material, the connection member is easily changed in shape for attachment to the bottom surface of the air intake chamber. The inner surface of the aperture of the air intake path thus can be easily formed to be continuous with the bottom surface of the air intake chamber.

[0168] Preferably, the fuel supply system has the injector injecting the fuel from the vicinity of the air guide portion.

[0169] With such a structure, the injector injects the fuel from the vicinity of the air guide portion. It means that the fuel is injected from the position away from the engine, and thus the fuel atomization can be facilitated to a greater extent.

[0170] Preferably, the fuel supply system has the injector injecting the fuel toward the aperture.

[0171] With such a structure, the injector injects the fuel toward the aperture, and thus the fuel does not bubble over that much toward outside of the air intake path. When the air intake path is plurally provided, the air-fuel ratio is almost the same among the air intake paths.

[0172] Preferably, the fuel supply system has the injector injecting the fuel with a timing coming into collision with shock waves that are generated in the engine and propagate through the air intake path in the direction toward the air intake chamber.

[0173] With such a structure, the injector injects the fuel with a timing coming into collision with the shock waves, and thus the fuel collided with the shock waves scatters, leading to fuel atomization with efficiency.

[0174] Preferably, the fuel supply system has the injector injecting the fuel with a timing coming into collision with the shock waves propagated into the air intake chamber.

[0175] With such a structure, the injector injects the fuel with a timing coming into collision with shock waves in the air intake chamber, and thus the fuel collided with the shock waves scatters in the wide space of the air intake chamber, leading to fuel atomization with more efficiency.

[0176] Preferably, the fuel supply system has the injector injecting the fuel with a timing when an air intake valve opens between the air intake path and the engine.

[0177] With such a structure, the injector injects the fuel with a timing when the air intake valve opens. Accordingly, the fuel collides with the shock waves to be produced in the air intake path responsively when the air intake valve opens, and thus the fuel atomization can be facilitated to a greater extent.

[0178] Preferably, the fuel supply system has the air intake path in which a plurality of apertures are included in the air intake chamber, and in the air intake chamber, the bottom surface among the apertures is formed with an edge line.

[0179] With such a structure, the bottom surface among the apertures of a plurality of air intake paths is formed with an edge line. Thus, the fuel splashed over the bottom surface among the apertures flows, without clogging, into the aperture at both ends with boundary of the edge line. Accordingly, in order to provide enough amount of fuel from the injector, there is no more need to control the amount of fuel to be injected from the injector, and to place the injector closer to the aperture of the air intake path.

[0180] Preferably, the fuel supply system has the air intake chamber in which an extended line of the edge line extends in the direction of the air guide portion.

[0181] With such a structure, the extended line of the edge line extends in the direction of the air guide portion, and thus an airflow is evenly produced along the bottom surface on the both sides of the edge line. This facilitates the fuel splashed over the bottom surface to vaporize, and more amount of fuel goes to the aperture. Accordingly, in order to provide enough amount of fuel from the injector, there is no more need to control the amount of fuel to be injected from the injector, and to place the injector closer to the aperture of the air intake path.

[0182] Additionally or alternatively to any embodiment of the invention as described above, an embodiment of a fuel supply system is disclosed, including: an air cleaner including an element for purifying air coming from outside; an air intake path including an aperture that opens toward inside of the air cleaner for guiding the purified air from the aperture to the engine; and an injector for injecting fuel between the element and the aperture. In the air cleaner, a bottom surface between the element and the aperture of the air intake path is sloped down toward the aperture, and in the air intake path, an inner surface of the aperture is continuous from the bottom surface.

[0183] Preferably, the air intake chamber forms part of the air cleaner. Preferably, the element is located between the intake chamber and the air guide portion.

[0184] With such a structure, the bottom surface between the element of the air cleaner and the aperture of the air intake path is sloped down toward the aperture, and is continuous with the inner surface of the aperture. Thus, the fuel from the element of the air cleaner splashed over the bottom surface among the apertures does not clog but flows into the air intake path. Accordingly, in order to inject the sufficient amount of fuel from the injector, there is no more need to control the amount of fuel to be injected from the injector, and to place the injector closer to the aperture of the air intake path. What is more, because the fuel is injected between the element and the aperture of the air intake path, the fuel can be better atomized with the air cleaner efficiently used in space. This thus favorably facilitates atomization of

fuel to be injected from the injector, and the engine performance can be improved with sufficient fuel supply when the engine is at the high speed and high load operation.

[0185] Additionally or alternatively to any embodiment of the invention as described above, an embodiment of a fuel supply system is disclosed, including: an air cleaner including an element for purifying air coming from outside; an air intake path including an aperture that opens toward inside of the air cleaner for guiding the purified air from the aperture to the engine; and an injector for injecting fuel between the element and the aperture. The air cleaner has such a structure that a bottom surface between the aperture and an inner wall opposite to the element including the aperture of the air intake path therebetween is sloped down toward the aperture, and the air intake path has an inner surface of the aperture formed continuous to the bottom surface.

[0186] With such a structure, the bottom surface between the aperture and the inner wall opposite to the element with the aperture of the air intake path of the air cleaner placed therebetween is sloped down toward the aperture, and is continuous with the inner surface of the aperture. Thus, the fuel from the inner wall at one end of the air cleaner splashed over the bottom surface between the apertures does not clog but flows into the air intake path. Accordingly, in order to inject the sufficient amount of fuel from the injector, there is no more need to control the amount of fuel to be injected from the injector, and to place the injector closer to the aperture of the air intake path. What is more, because the fuel is injected between the element and the aperture of the air intake path, the fuel can be better atomized with the air cleaner efficiently used in space. This thus favorably facilitates atomization of fuel to be injected from the injector, and the engine performance can be improved with sufficient fuel supply when the engine is at the high speed and high load operation.

[0187] Additionally or alternatively to any embodiment of the invention as described above, an embodiment of a fuel supply system is disclosed, including: an air intake chamber including an element for purifying air coming from outside, and a through hole that is formed, to go through outside of the chamber, at the lowest portion of an inner surface of the chamber into which the air passed through the element flows; an air intake path for guiding the air through the through hole from the air intake chamber; and an injector for injecting fuel inside of the air intake chamber toward a portion upper than the through hole.

[0188] With such a structure, the air is directed to the air intake path from the through hole that is formed at the lowest position of the inner surface of the air intake chamber, and the fuel is injected toward the part upper than the through hole. Therefore, the fuel splashed over the inner surface of the air intake chamber flows over the inner surface of the chamber into the air intake path from the through hole, and the air having passed through the element is vaporized by the airflow flowing in the air intake chamber in its entirety. Accordingly, in order to inject the sufficient amount of fuel from the injector, there is no more need to control the amount of fuel to be injected from the injector, and to place the injector closer to the air intake path. What is more, because the fuel is injected to the part upper than the through hole, the fuel can be better atomized with the air intake chamber efficiently used in space. This thus favorably facilitates atomization of fuel to be injected from the injector, and the engine performance can be improved with sufficient fuel supply when an engine is at the high speed and high load operation.

[0189] According to a further preferred embodiment which, as every other embodiment, is combinable with any other embodiment, the fuel supply system has the air intake chamber including a small-diameter portion formed by an inner edge wall surface of the through hole protruding toward a center, and the air intake path includes: a connection member made of an elastic body for attachment to the small-diameter portion; and a tubular member for coupling to the connection member.

[0190] With such a structure, the connection member made of an elastic body is attached to the small-diameter portion that is formed by the inner edge wall surface of the through hole protruding toward the center, and this connection member is coupled with the tubular member so that the air intake path is formed. Accordingly, any dimension error observed in the through hole or tubular member can be absorbed by the connection member, and thus the air intake path is closely attached to the through hole. Further, any vibrations of the tubular member are absorbed by the connection member, and thus vibration transfer to the air intake chamber can be suppressed. Accordingly, any vibrations of the engine can be prevented from being transferred from the tubular member to the air intake chamber. Even if the injector is attached to the air intake chamber, the fuel supply from the injector can be stable.

[0191] Preferably, the fuel supply system is further provided with an engagement member for engaging between the air intake chamber and the air intake path, and the tubular member is engaged by the engagement member from the air intake chamber, and the connection member is partially held firmly by the small-diameter portion and the tubular member.

[0192] With such a structure, the tubular member is engaged by the engagement member from inside of the air intake chamber, and the connection member is partially held firmly by the small-diameter portion of the through hole and the tubular member. Accordingly, the connection member can be securely fixed by the small-diameter portion and the tubular member, and the air intake path can be shortened in length compared with an exemplary case of fixing together the connection member and the tubular member using a band for wrapping therearound. This thus favorably leads to system downsizing.

[0193] Preferably, the fuel supply system has the connection member including a protrusion that protrudes into the air intake chamber, and the protrusion covers a part of the engagement member.

[0194] With such a structure, the protrusion protruding into the air intake chamber covers a part of the engagement member. Accordingly, even if the engagement member is loosened and comes off due to vibrations, the protrusion stops the engagement member not to move, and the engagement member does not find its way to the air intake path from the through hole.

[0195] As further explained above, according to a further embodiment of the invention, a vehicle including a fuel supply system as disclosed in at least in one embodiment described in this specification, is disclosed.

[0196] Therefore, the vehicle can implement the same effects as the described fuel supply system.

[0197] According to a further preferred embodiment, the vehicle further includes an air intake port for capturing a running wind flowing from front to rear when the vehicle moves; and an air intake duct for forwarding the captured running wind to the air intake chamber. The air intake chamber is placed rear to the air intake port.

[0198] With such a structure, the air intake chamber is placed behind the air intake port for capturing the running wind. Accordingly, the airflow in the air intake duct and the air intake chamber picks up momentum by the running wind, and thus the flow velocity of the airflow in the air intake chamber is increased, and the fuel splashed in the air intake chamber can be vaporized to a greater extent.

[0199] As described above, a fuel supply system is provided, being of the structure, including: an air intake chamber including an air guide portion for guiding air; an air intake path including an aperture that opens toward inside of the air intake chamber for guiding the air in the air intake chamber from the aperture to an engine; and an injector provided inside of the air intake chamber for injecting fuel between the air guide portion and the aperture, and in the air intake path, an inner surface of the aperture is continuous to a bottom surface of the air intake chamber.

[0200] Additionally or alternatively, a fuel supply system is provided being of the structure, including: an air intake chamber including an element for purifying air coming from outside, and a through hole that is formed, to go through outside of the chamber, at the lowest portion of an inner surface of the chamber into which the air passed through the element flows; an air intake path for guiding the air through the through hole from the air intake chamber; and an injector for injecting fuel inside of the air intake chamber toward a portion upper than the through hole.

[0201] Such structures eliminate the need for suppressing the amount of fuel coming from the injector, or bringing the injector closer to the aperture of the air intake path, successfully allowing sufficient fuel supply from the injector. What is more, the fuel can be better atomized with the air intake chamber efficiently used in space. This thus favorably facilitates atomization of fuel to be injected from the injector, and the engine performance can be improved with sufficient fuel supply when the engine is at the high speed and high load operation.

[0202] Accordingly, fuel coming from the injector can be better atomized, and the engine performance can be improved with sufficient fuel supply when the engine is at the high speed and high load operation.

[0203] As explained, one essential aspect of the invention is the shape of an aperture whose inner surface on the air cleaner side in the air intake path is so formed as to be continuous to the bottom surface of the air cleaner so that fuel clogging can be prevented on the bottom surface of the air cleaner.

[0204] As further explained above, in order to facilitate atomization of fuel to be injected from an injector, and to improve the engine perfomance with enough fuel supply when an engine is at the high speed and high load operation, a fuel supply system is provided comprising at least one of the following features or advantages: An aperture 24a of the air funnel 24 that opens toward inside of a main chamber 5b of an air cleaner 5 has the same diameter as a through hole between a bottom surface front portion 4d and a bottom surface rear portion 4e. The inner surface of the aperture 24a of the air funnel 24 is curved to be continuous with both the bottom surface front portion 4d and the bottom surface rear portion 4e. That is, the area in the vicinity of the aperture 24a of the air funnel 24 is formed to look like a funnel. With such a structure, the fuel splashed over the bottom surface of the air cleaner 5 flows, without clogging, from the air funnel 24 into an air intake path 9. There is thus no more need to place the aperture 24a closer to an upstream injector 18, and to control the amount of fuel to be injected from the upstream injector 18.

Claims

1. Fuel supply system, comprising:

   an air intake chamber (5b) having an air inlet opening;
   an air intake path (9) including an aperture (24a,42a) that opens towards
   an inside of the air intake chamber (5b) for guiding the air in the air intake chamber (5b) from the aperture (24a,42a) to an engine (13); and
   an injector (18) for injecting fuel between the air inlet opening and the aperture (24a,42a), **characterized in that** in the air intake path (9), an inner surface of the aperture (24a,42a) is continuous to a bottom surface (4d,4e) of the air intake chamber (5b).

2. Fuel supply system according to claim 1, **charac-**

terized in that the injector (18) is provided inside of the air intake chamber (5b), and/or **in that** in the air intake chamber (5b), the bottom surface (4d,4e) is sloped downwardly towards an outer edge of the aperture (24a,42a) of the air intake path (9), wherein preferably the bottom surface (4d,4e) is sloped at an angle (α,β) of 45 degrees or less with respect to a horizontal plane (H).

3. Fuel supply system according to claim 1 or 2, **characterized in that** the air intake chamber (5b) is configured to be capable of producing an airflow by the air from the air inlet opening along the bottom surface (4d,4e) toward the aperture (24a,42a).

4. Fuel supply system according to at least one of the claims 1 to 3, **characterized in that** the air intake path (9) comprises:

    a connection member (24,42) that forms the aperture (24a,42a) which preferably goes through the bottom surface (4d,4e) of the air intake chamber (5b) from an inside of the air intake chamber (5b) towards an outside thereof; and wherein preferably a tubular member (26) configured to establish a connection with the connection member (24) from the outside of the air intake chamber (5b), and/or wherein preferably the connection member (24,42) is made of an elastic material.

5. Fuel supply system according to at least one of the claims 1 to 4, **characterized in that** the injector (18) is configured to inject the fuel from a vicinity of the air inlet opening, and/or **in that** the injector (18) is configured to inject the fuel toward the aperture (24a,42a).

6. Fuel supply system according to at least one of the claims 1 to 5, **characterized in that** the injector (18) is configured to inject the fuel with a timing coming into collision with a shock wave that is generated in the engine (13) and which propagates through the air intake path (9) in a direction toward the air intake chamber (5b), wherein preferably the injector (18) is configured to inject the fuel with a timing coming into collision with the shock wave propagated into the air intake chamber (5b).

7. Fuel supply system according to at least one of the claims 1 to 6, **characterized in that** the injector (18) is configured to inject the fuel with a timing when an air intake valve (13b) opens between the air intake path (9) and the engine (13).

8. Fuel supply system according to at least one of the claims 1 to 7, **characterized in that** in the air intake path (9), the aperture (24a,42a) comprises a plurality of apertures (24a,42a) being included in the air intake chamber (5b), wherein preferably in the air intake chamber (5b), a bottom surface (4d,4e) among the apertures is formed with an edge line (4i), wherein further preferably in the air intake chamber (5b), an extended line of the edge line (4i) extends in a direction of the air inlet opening.

9. Fuel supply system according to at least one of the claims 1 to 8, **characterized in that** the air intake chamber (5a) is comprised in an air cleaner (5) including an element (8) for purifying air coming from outside, wherein preferably the element (8) is provided upstream of the injector (18) which is arranged to inject fuel between the element (8) and the aperture (24).

10. Fuel supply system according to at least one of the claims 1 to 9, **characterized in that** in the air intake chamber (5b), a bottom surface (4d,4e) between the aperture (24a,42a) and an inner wall opposite to an element for purifying intake air, the bottom surface (4d,4e) including the aperture (24a,42a) of the air intake path (9) therebetween is sloped downwardly towards the aperture (24a,42a).

11. Fuel supply system according to at least one of the claims 1 to 10, **characterized in that** the air inlet opening comprises an air guide portion (4b) for guiding air at a section of the air intake chamber (5b) being upstream of the aperture (24a,42a), wherein, preferably, at least a part of the air guide portion (4b) is provided upstream of the injector (18).

12. Fuel supply system, in particular according to at least one of the claims 1 to 11, **characterized by** comprising:

    an air intake chamber (5b) including an element (8) for purifying air coming from outside, and a through hole that is formed, to go through outside of the intake chamber (5b), at a lowest portion of an inner surface of the intake chamber (5b) into which the air passed through the element (8) flows;
    an air intake path (9) for guiding the air through the through hole from the air intake chamber (5b); and
    an injector (18) for injecting fuel inside of the air intake chamber (5b) toward a portion upper than the through hole.

13. Fuel supply system according to at least one of the claims 1 to 12, **characterized in that** the air intake chamber (5b) includes a small-diameter portion (4h) formed by an inner edge wall surface of a through hole protruding toward a center, and/or the

air intake path includes:

a connection member (24,42) made of an elastic material, for attachment to the small-diameter portion (4h); and
a tubular member (26) for coupling to the connection member (24,42).

14. Fuel supply system according to at least one of the claims 1 to 13, **characterized by** further including an engagement member (38) for engaging between the air intake chamber (5b) and the air intake path (9), wherein a tubular member (26) of the intake path (9) is engaged by the engagement member (38) from an inside of the air intake chamber (5b), and/or in that a connection member (24,42) connecting the air intake path (9) and the intake chamber (5b) is partially held firmly by the small-diameter portion (4h) and the tubular member (30).

15. Fuel supply system according to claim 14, **characterized in that** a connection member (24,42) includes a protrusion (24c,42c) that protrudes into the air intake chamber (5b), and wherein preferably the protrusion (24c,42c) covers at least partially the engagement member (38).

16. Fuel supply system according to least one of the claims 1 to 15, **characterized in that** a second injector (30) is arranged to inject fuel into the air intake path (9) at a position downstream of the aperture (24a,42a).

17. Fuel supply system according to at least one of the claims 1 to 16, **characterized in that** a throttle valve (30) is provided, which is positioned downstream of the aperture (24a,42a) and/or upstream of the second injector (30).

18. Fuel supply system according to at least one of the claims 1 to 17, **characterized in that** the injector (18) is provided to be located at least partially within the intake chamber (5b).

19. Fuel supply system according to at least one of the claims 1 to 18, **characterized in that** the injector (18) is provided to be located at least partially outside the intake chamber (5b).

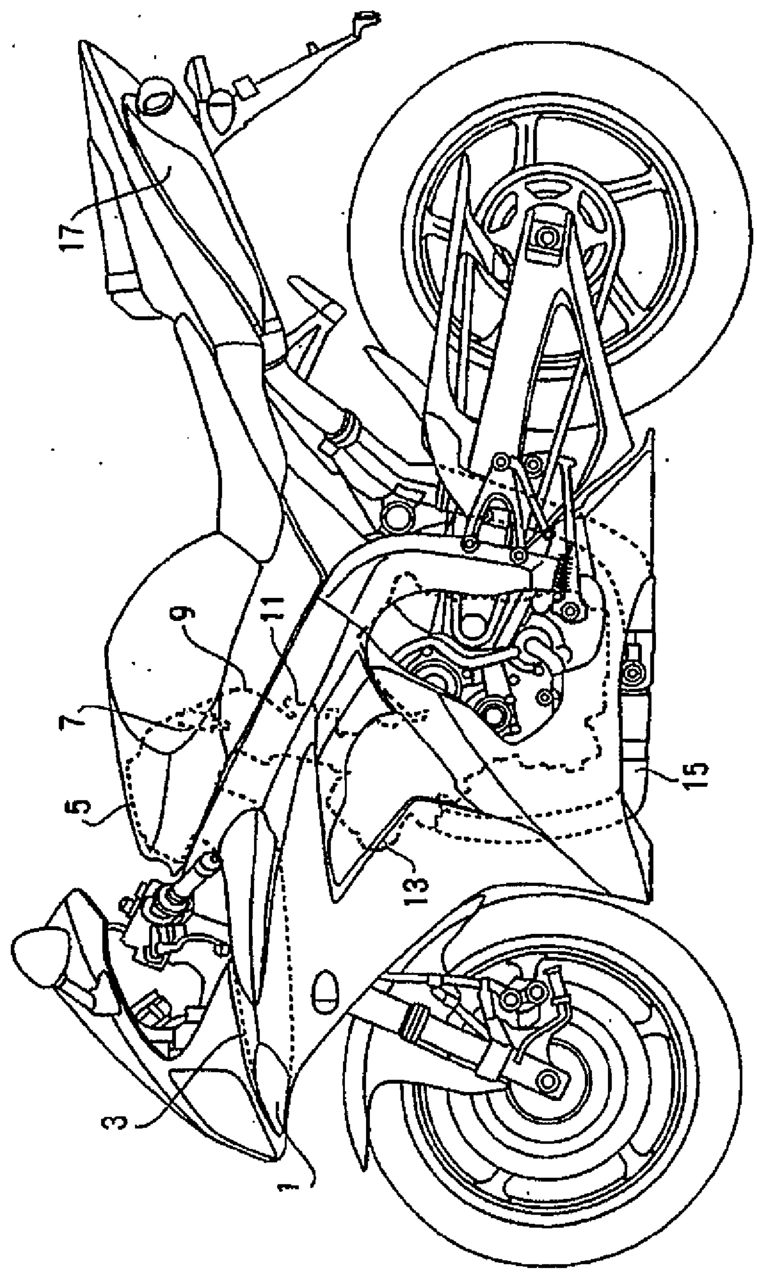
20. Fuel supply system according to at least one of the claims 1 to 18, **characterized in that** the injector (18) is provided to be located completely within the intake chamber (5b).

21. Vehicle, in particular being a straddle-type vehicle, comprising an engine (13) and a fuel supply system, **characterized in that** the fuel supply system is configured according to at least one of the claims 1 to 20.

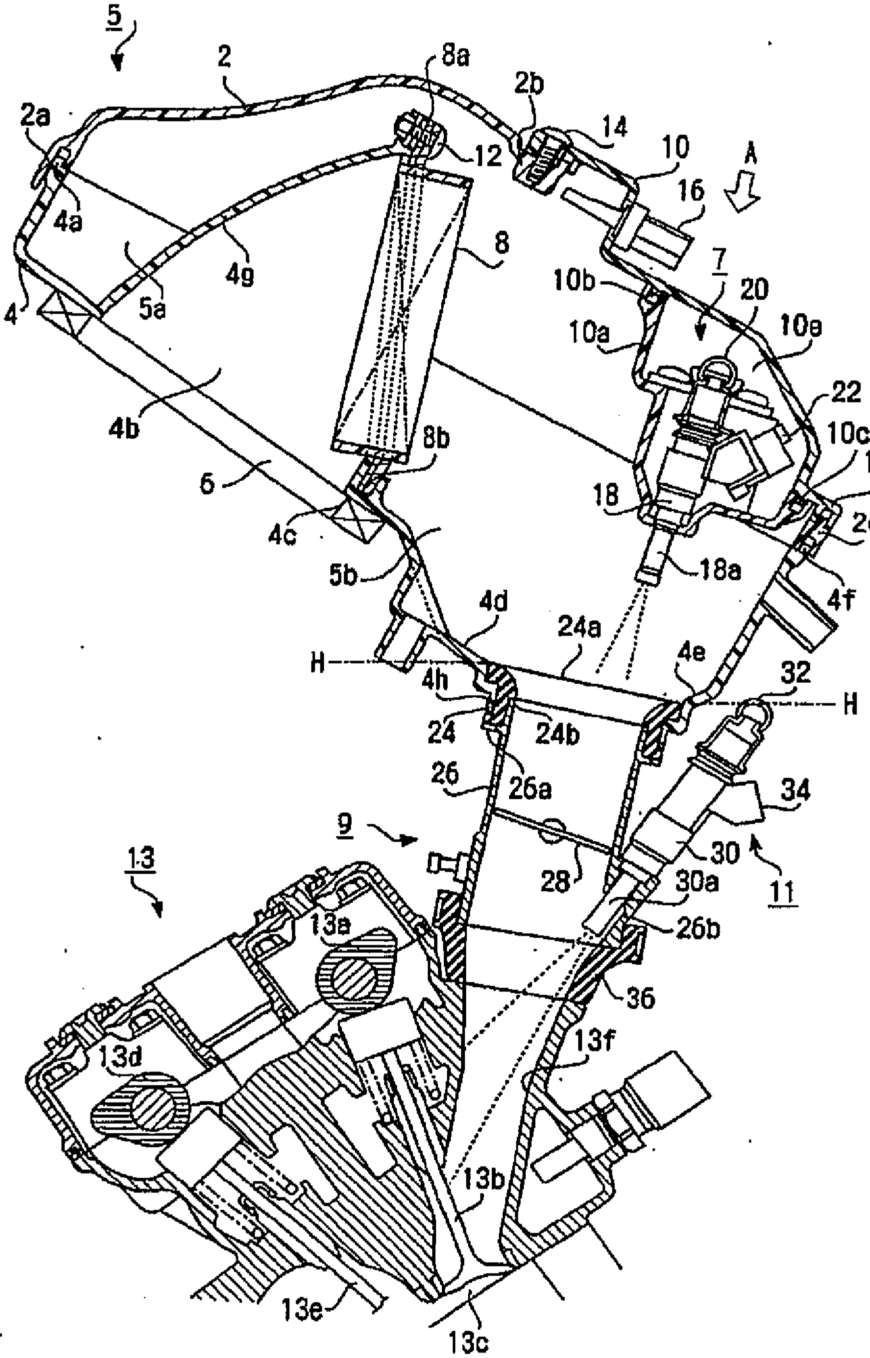
22. Vehicle according to claim 21, **characterized by** further comprising:

an air intake port for capturing a running wind flowing from front to rear when the vehicle moves; and
an air intake duct (3) for forwarding the captured running wind to an air inlet opening of the air intake chamber (5b),
the air intake chamber (5b) preferably being placed rearwardly of the air intake port.

[FIG. 1]



[FIG. 2]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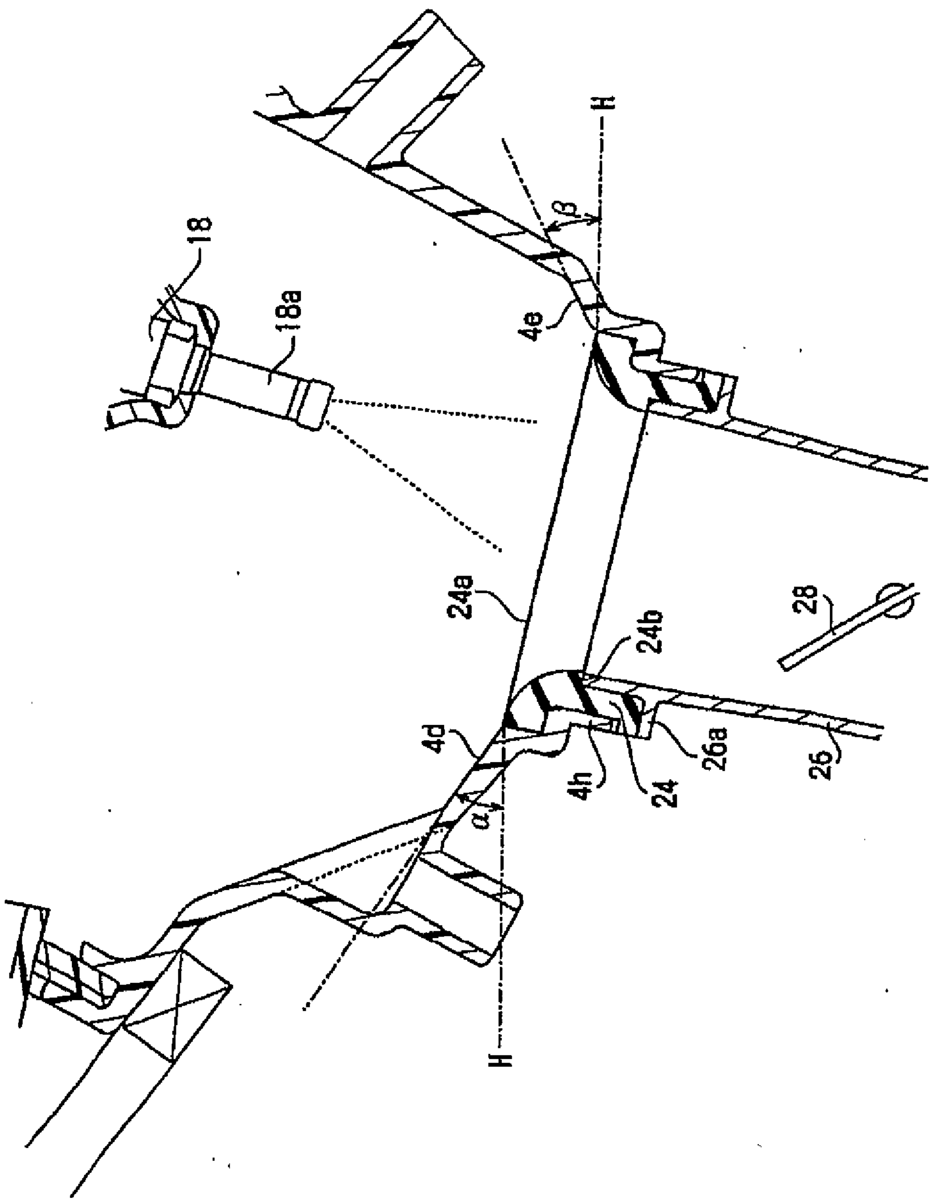
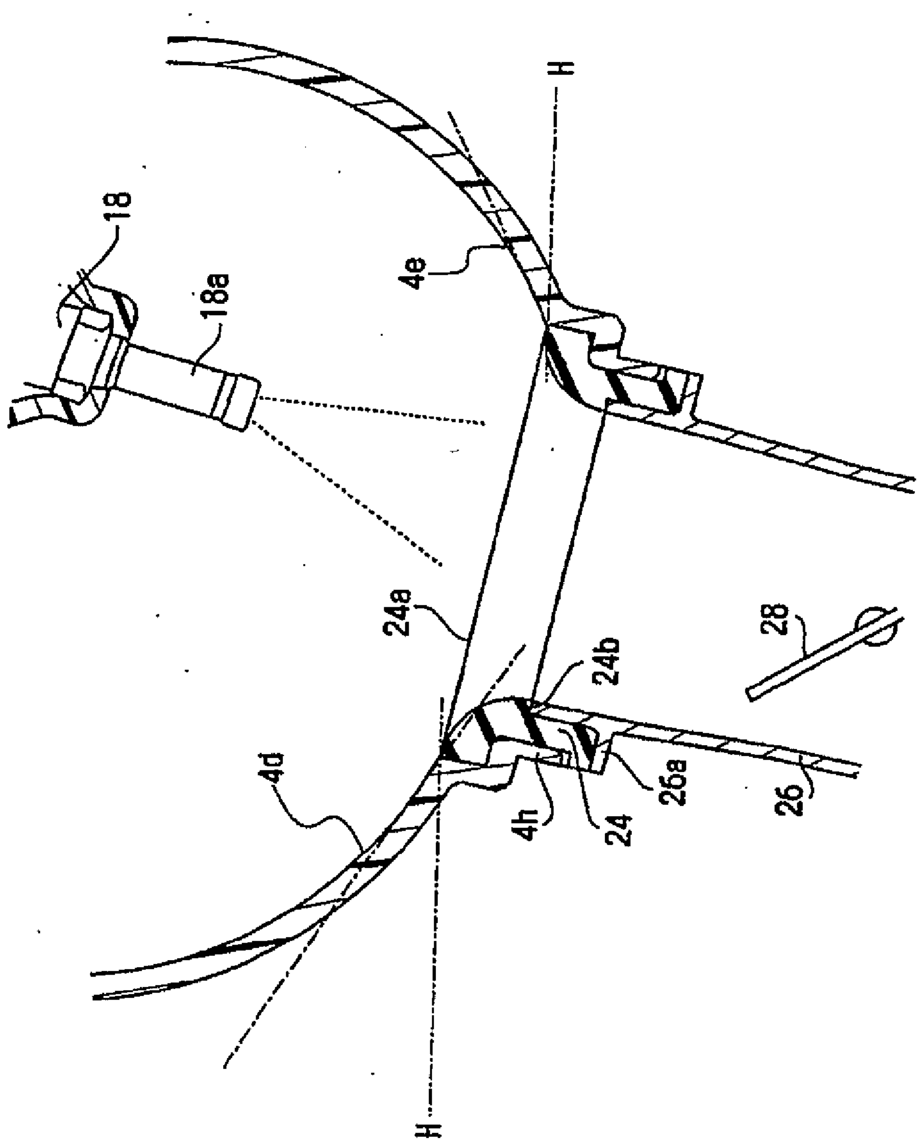
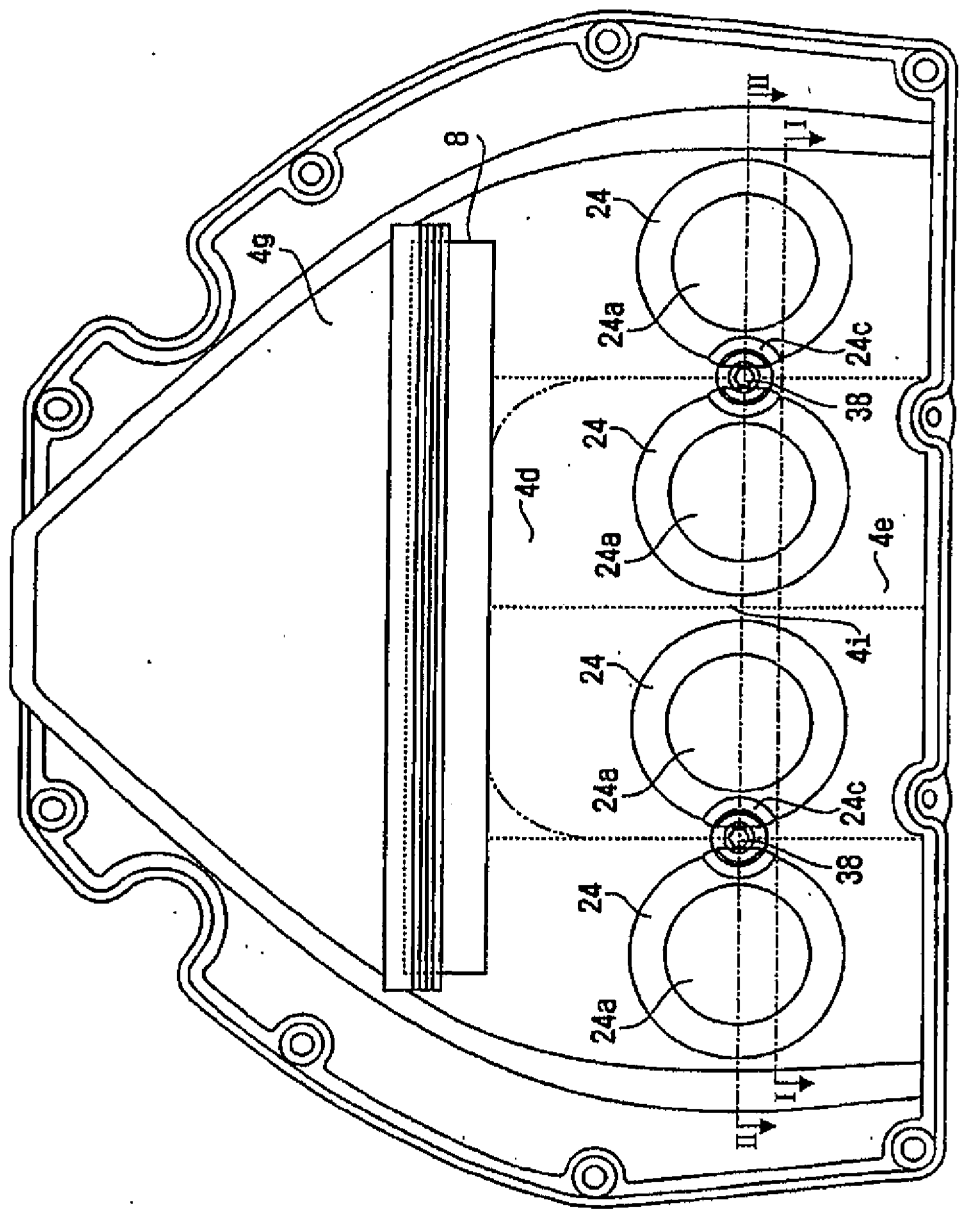
[FIG. 3]



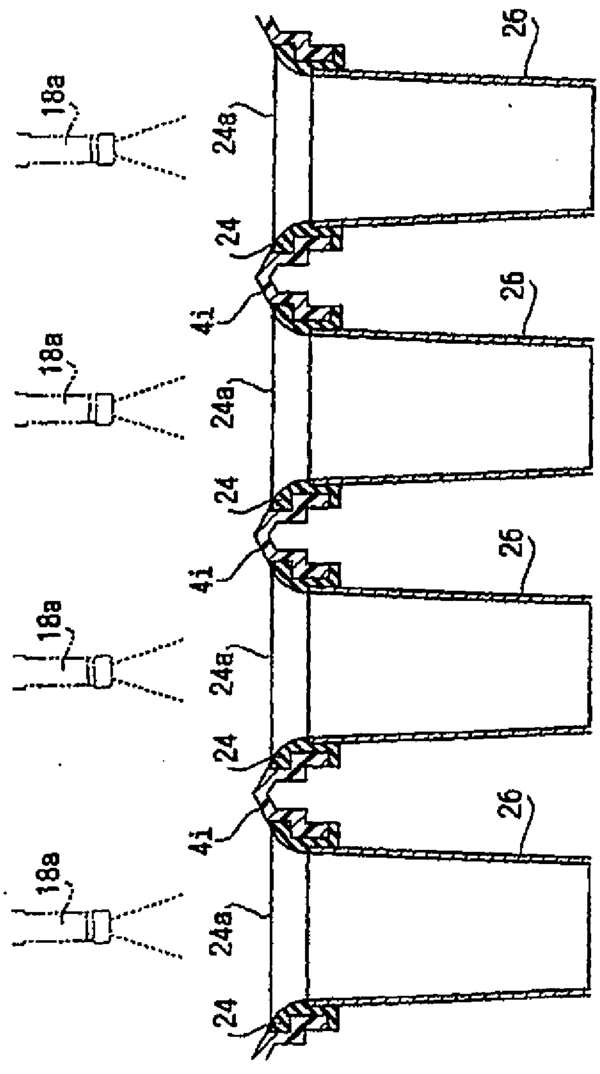
[FIG. 4]



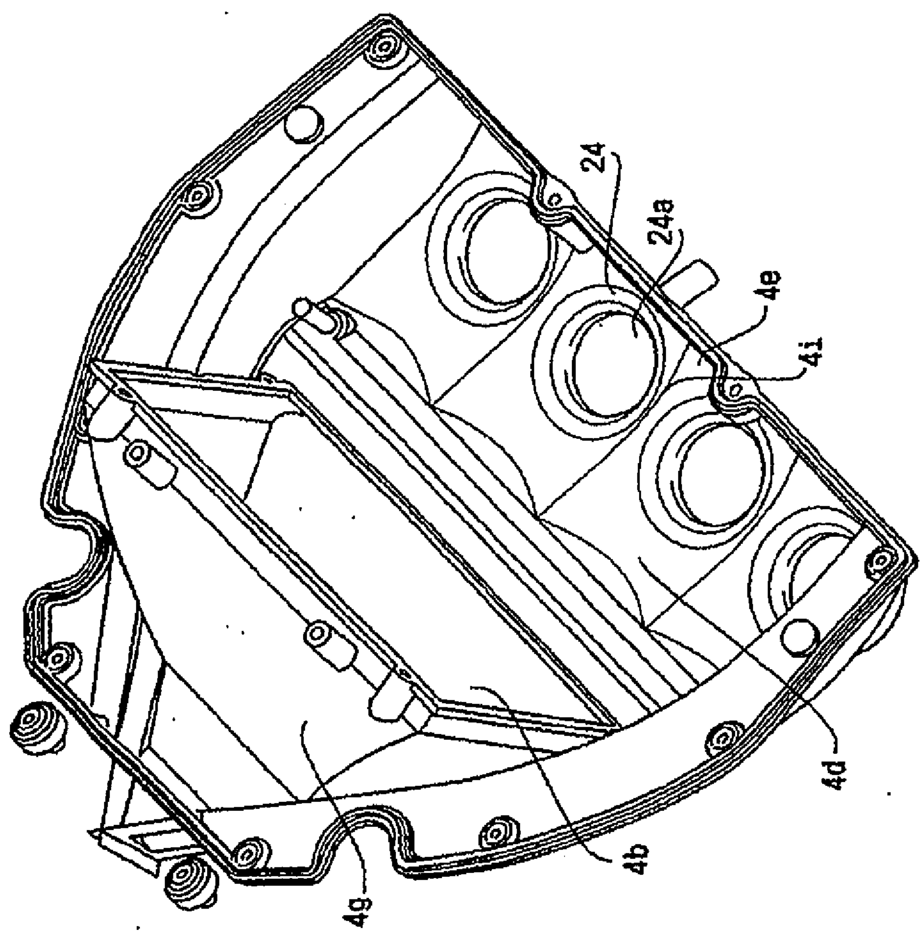
[FIG. 5]



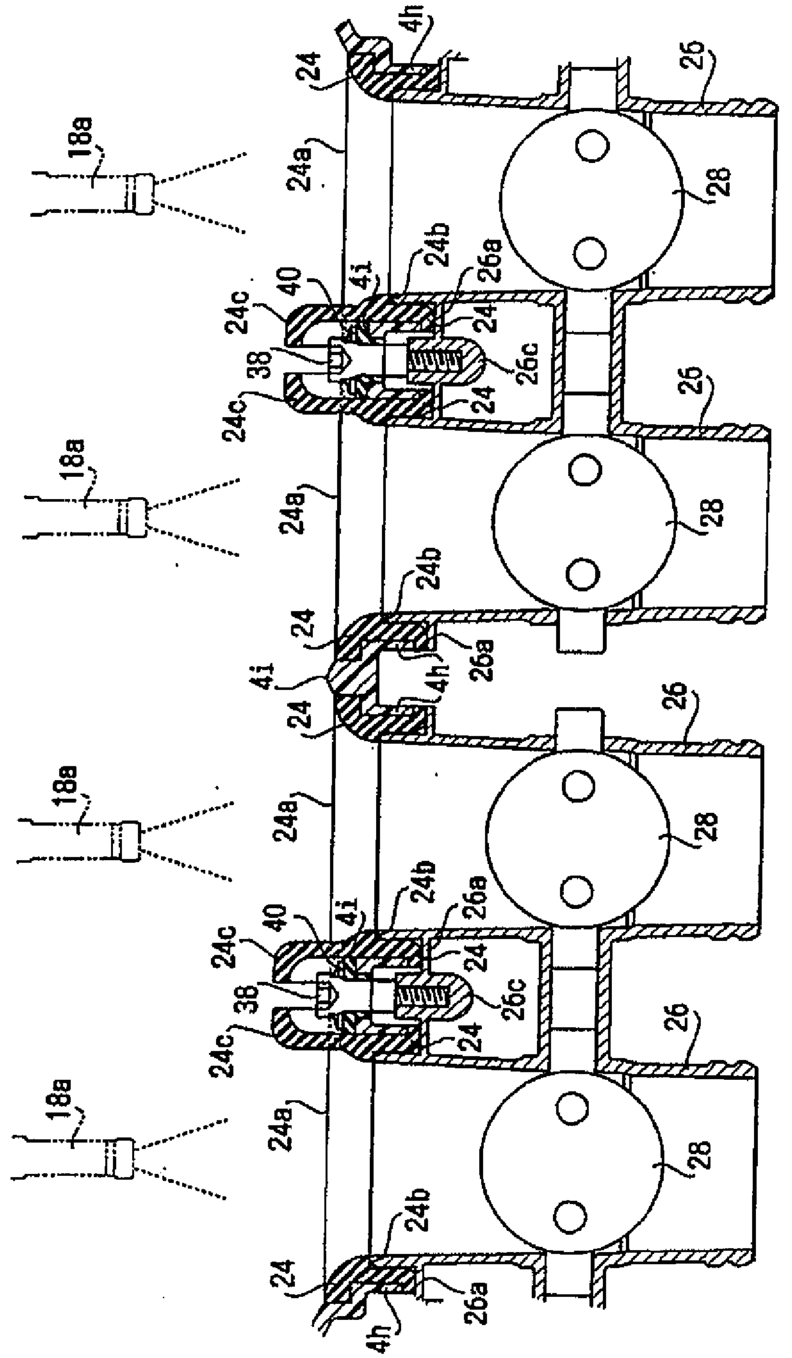
[FIG. 6]



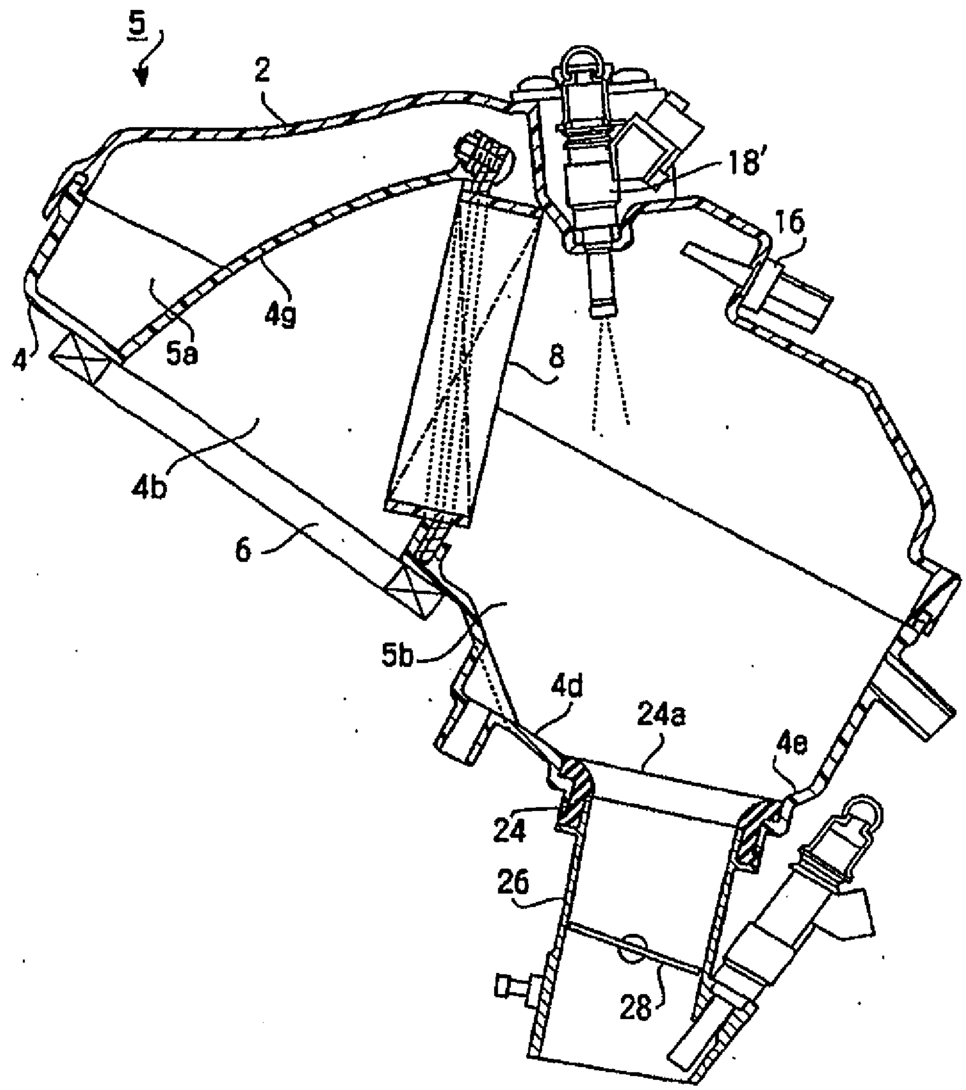
[FIG. 7]



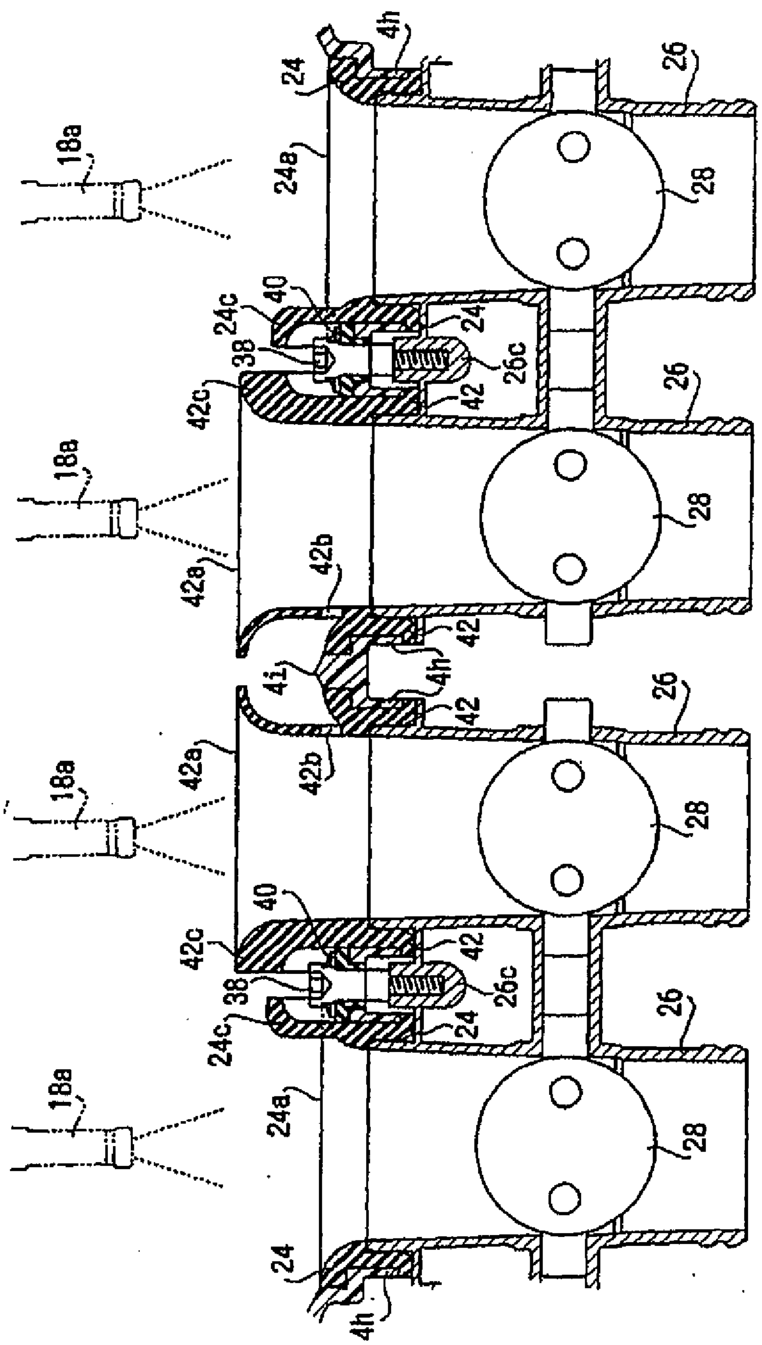
[FIG. 8]



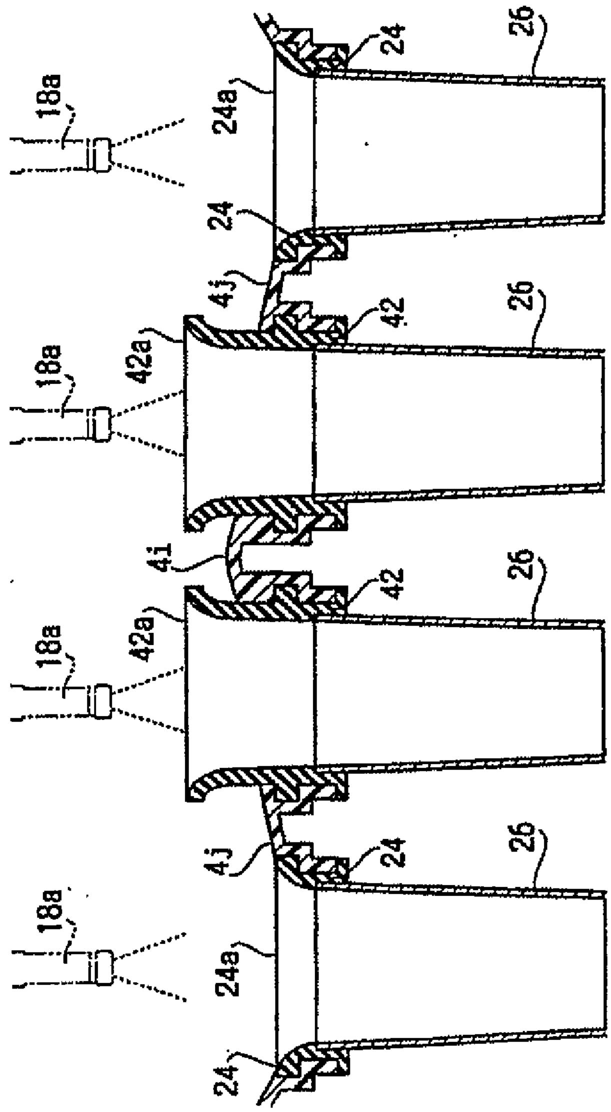
[FIG. 9]



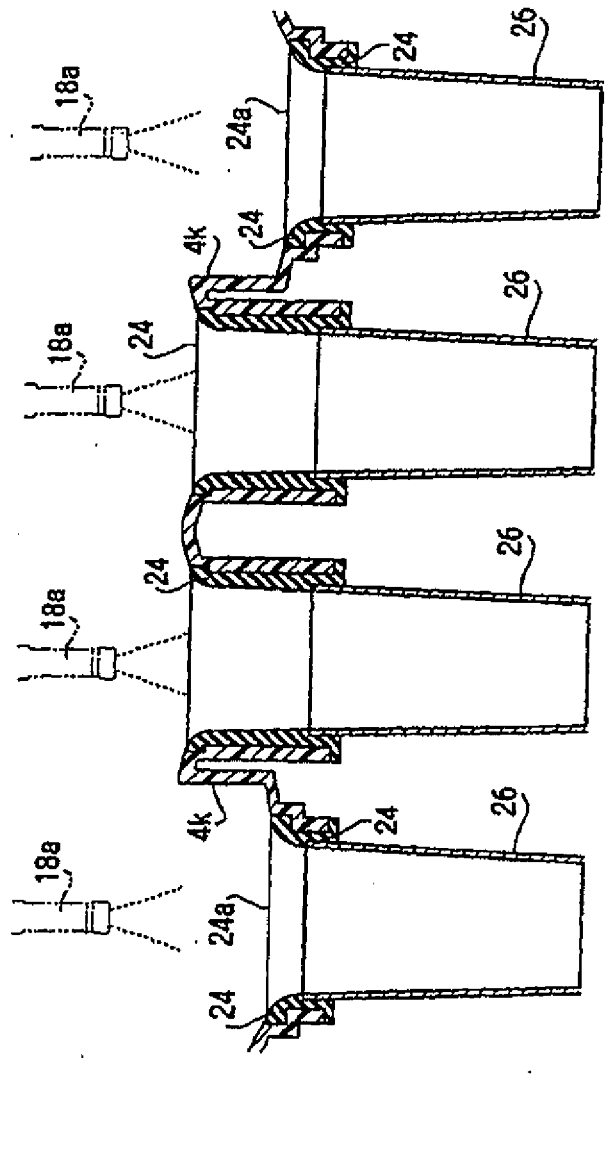
[FIG. 10]



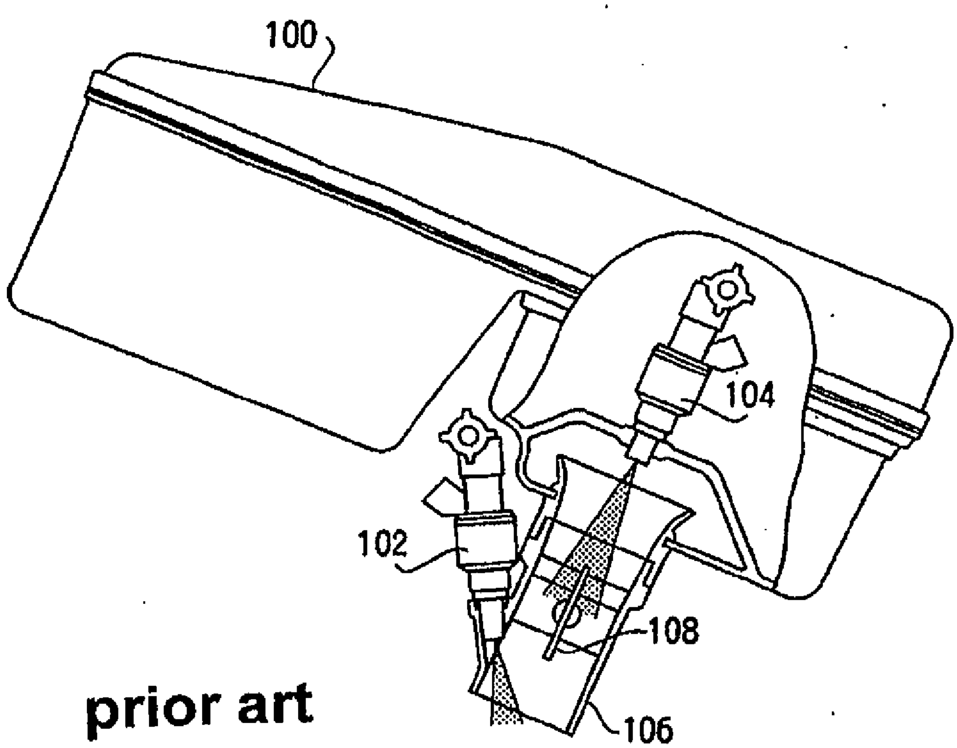
[FIG. 11]



[FIG. 12]



[FIG. 13]



European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 05 00 6312

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X	GB 2 009 843 A (GENERAL MOTORS CORP) 20 June 1979 (1979-06-20)	1-3,5,9, 11-13, 17,18, 20-22	F02M61/14 F02M69/04 F02M35/10
A	* page 2, line 19 - line 50; figures 1,5 * * page 2, line 97 - line 104 * -----	6-8,16, 19	
A	EP 1 387 081 A (YAMAHA HATSUDOKI KABUSHIKI KAISHA) 4 February 2004 (2004-02-04) * paragraph [0034] - paragraph [0036]; figure 2 * -----	1-3,5, 8-13, 16-18, 20-22	
A	WO 01/79690 A (SEM AB; ALMKVIST, GOERAN) 25 October 2001 (2001-10-25) * page 1, line 31 - page 2, line 19; figures 1-3 * -----	6,7	
A	EP 1 293 653 A (DUCATI MOTOR HOLDING S.P.A) 19 March 2003 (2003-03-19) * paragraph [0041] - paragraph [0042]; figures 1-4 * -----	19	TECHNICAL FIELDS SEARCHED (Int.Cl.7) F02M
A	EP 0 169 481 A (HITACHI, LTD) 29 January 1986 (1986-01-29) * abstract; figure 2 * -----	1	
A	EP 1 396 633 A (HONDA GIKEN KOGYO KABUSHIKI KAISHA) 10 March 2004 (2004-03-10) * paragraph [0004]; figures 1,7 * -----	1	

3

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	7 July 2005	Kolland, U

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
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P : intermediate document

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E : earlier patent document, but published on, or after the filing date
D : document cited in the application
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